THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

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Chronicle and Comment

Robinson Joins Convention Bureau

AFTER 6 years of service with the Society in many capacities, Francis T. Robinson has become General Manager of the Convention Bureau, Inc., with offices in New York City. Mr. Robinson rendered valuable assistance in several phases of the Society's activities, including the employment service, meetings, and membership increase. It is hoped that he will be very successful in his new work.

Looking Ahead

ALTHOUGH the Transportation and Service Meeting is more than 3 months in the future and the Tractor Meeting 4 months off, plans for the two gatherings are practically completed at this date. The committees in charge of these meetings are to be commended for their splendid enthusiasm and zeal which brought about this desirable condition. The Transportation and Service Meeting will convene at Boston on Nov. 16 to 18; the Tractor Meeting, at Chicago, early in December.

Society Finances

THE gross income of the Society for the first 9 months of the current fiscal year was approximately $269,000. This is $21,000 in excess of the budget figure, and about $50,000 more than the gross income for the corresponding period of last year. The increased expense for the period as compared with last year was about $23,000. On June 30 last the net unexpended income for the 9 months' period was approximately $14,000. This is comparable with a deficit of $13,000 for the corresponding period of last fiscal year.

Interesting to Production Men

PAPERS relating to such important production problems as conveyors, inspection, machine tools, and gear production will be presented at the Production Meeting in Chicago on Sept. 21 to 23, ample time being allowed for discussion during each session. Inspection visits to industrial plants will lend variety to the program, and the Stag Carnival, which will be the chief social event of the meeting, will doubtless be a superlatively enjoyable event. Advance information regarding this event is printed elsewhere in this issue of THE JOURNAL, and further details will appear in the September issue of THE JOURNAL and in *Meetings Bulletins*.

The Aeronautic Meeting

INCREASED attention is being given throughout this Country, and in fact throughout the world, to matters aeronautical. Important developments are being constantly made, and marked progress in the near future is eagerly anticipated. This state of affairs augurs well for the success of the Society's Aeronautic Meeting that will be held in Philadelphia on Sept. 2 and 3, when distinguished engineers and executives will present uptodate information that will be of intense interest to all concerned with aeronautics.

Details concerning the Aeronautic Meeting, including the program, will be found elsewhere in this issue.

It Pays to Plan

ONE Section was commended in these columns last month for its forehandedness in planning its year's work well in advance. Reports from other Sections that have come in during the last month indicate that the value of this procedure is realized rather generally, as a number of the Sections have already arranged, at least tentatively, a program for their 1926-7 activities. This practice of looking ahead not only results in appreciably better Section meetings but saves time for the Governing Committees.

An ingenious calculator has estimated the time consumed at two Governing Committee meetings during the summer to plan an entire year's work for a Section and has also figured out the time that must be given when Governing Committee meetings are held throughout the year to plan the program one meeting at a time. He shows that the latter practice, which almost invariably gives poorer results, takes about 10 hr. longer for each person concerned than does the plan-in-advance method.

Fifty-Ton Road-Loads Coming?

NOTHING is more important from an economic standpoint in the fostering of the National welfare than the location and grades and the general features of the construction of highways. H. L. Brightman, engineer of surveys of the Michigan State Highway Department, said recently with regard to modern highway building that

looking ahead properly involves modification of current ideas in this connection. He quoted a member of the Society as saying that in the near future we shall see loads of 50 tons or more traversing the highways in regularly scheduled trains of tractors and trailers. This member has made a special study of heavy-duty trailer work. Obviously, the opinion that Mr. Brightman has expressed is correct, namely, that progress in the road motor-vehicle world is so rapid that what we now consider adequate in road building will within very few years be seen plainly to be insufficient. The achievements that the highway engineer can accomplish are of course limited by the money available for his work, but clear conception is requisite on his part of the inexorable demand of road traffic in the coming years with respect to volume, load and speed.

The Sections Are Growing

COMPARATIVE figures have been assembled showing Sections membership as of July 1, in the years 1924, 1925 and 1926. Ten Sections in 1924 had 1229 members; 11 Sections in 1925 had a membership of 2329; 13 Sections now possess a total of 2819. In other words, the increase in 1925 over 1924 was nearly 90 per cent; an approximate increase, in 1926, of 21 per cent over 1925 and of 129 per cent over 1924. Detail figures are given herewith in tabulated form.

MEMBERSHIP OF SECTIONS AS OF JULY 1, 1924, 1925 AND 1926

Section	1926	1925	1924
Buffalo	94	68	47
Chicago	279	243	122
Cleveland	266	237	137
Dayton	66	93	62
Detroit	756	628	378
Indiana	103	88	44
Metropolitan	638	530	327
Milwaukee	92	83	...
New England	130	135	35
Northern California	54	...	...
Pennsylvania	213	175	64
Southern California	68	...	...
Washington	60	49	13
	2,819	2,329	1,229

Even if no new Sections had been formed during the periods mentioned, with the other facts the same the 1925 increase would have been 83 per cent; the increase of 1926 over 1925 would have been 16 per cent; and of 1926 over 1924 would have been 112 per cent. The inactive Minneapolis Section is not included in these figures.

Present indications point to a period of even greater prosperity and growth for the Sections in the immediate future. Attractive meetings are essential to the growth of a Section, and a strong and active Membership Committee can do much to accelerate such development.

Production Committee To Be Formed

AS the result of conferences held in Cleveland and Detroit by members of the Society who are directly interested in production work, it has been decided to organize a Production Committee of the Society in a manner analogous to that in which the Motor-Vehicle Operation and Maintenance Committee was recently established. The latter Committee is to encourage and develop interest and activity in the Society's work that will be most beneficial to members representing motorcoach and motor-truck fleet-operators. A survey of the automotive manufacturing field will be made to enlist the cooperation of the production men of the industry, especially those who would be key men in the further development of the Society's production activities.

The efforts of the Committee will be devoted principally to developing activities of interest to production members with relation to standardization, research, presentation of papers, and the holding of meetings, both Section and national. Part of the plan of organization is to have production committees in the local Sections, particularly in Detroit, Cleveland, Milwaukee, and Chicago, to develop and carry through programs of interest in their vicinity. The Production Division of the Standards Committee that was instituted this year will take an active interest in the further development of the production activities as it is felt that much of the new committee's work will deal largely with standardization.

Those attending the Cleveland conference were Eugene Bouton, A. H. Frauenthal, Ferdinand Jehle, E. N. Sawyer, J. A. C. Warner, and R. S. Burnett. The conference at Detroit was attended by President T. J. Litle, Jr., L. C. Hill, First Vice-President J. H. Hunt, V. P. Rumely, J. A. C. Warner, Standards Committee Chairman F. A. Whitten and R. S. Burnett.

Burkhardt Returns to the Industry

OTTO M. BURKHARDT, who has been Manager of the Research Department of the Society since March of last year, is relinquishing that position to become associated with the Buick Motor Co., Flint, Mich., at an early date. Mr. Burkhardt is now abroad visiting his parents.

When Mr. Burkhardt joined the Society staff he stated formally that every effort would be made by the Research Department to assist the automotive industry to assure greater appreciation and more extensive use of applied science in the furthering of systematic design and the testing of the major unit-assemblies that constitute the basis of automotive engineering and in turn of the whole industry. Accordingly, Mr. Burkhardt proceeded to make an analytical investigation of the problems involved in designing to obviate squeaking, chattering and grabbing of motor-vehicle brakes. In June of last year he presented at the Summer Meeting of the Society a paper entitled Fundamentals of Brake Design.

Following out work inaugurated by the Research Committee in June, 1924, Mr. Burkhardt compiled for publication in THE JOURNAL articles on the causes of and practical remedies for crankcase-oil contamination. In addition, he collated and interpreted data based on analyses of about 650 samples of contaminated oil. He presented a paper on this general subject at the meeting of the Society held at French Lick Springs last June.

In connection with studies made to ameliorate conditions of motor-vehicle head-lamp illumination, Mr. Burkhardt prepared several reviews for publication in THE JOURNAL and also drafted an outline of a research program looking toward joint effort of car and lamp manufacturers in the solving of head-lamp problems. This was reflected largely in the general research program on the subject that was approved last January.

Mr. Burkhardt also directed his energy to encouraging cooperation of makers of cars, tires, shock-absorbers, and springs, and of officials of the Bureau of Public Roads, on the subject of riding-qualities of motor vehicles. Similar efforts were made in connection with research on the durability, quietness and efficiency of gears, reviews of pertinent developments being published.

Mr. Burkhardt worked earnestly and enthusiastically on various elements of the Research Department work. Best wishes for him in his new position.

MEETINGS OF THE SOCIETY

News accounts of National and Section meetings that were held during the preceding month, as well as announcements of forthcoming meetings, are presented in this department

AERONAUTIC MEETING NEXT

Three Technical Sessions, a Banquet and an Inspection Trip Planned

Intense and widespread interest is being manifested toward the Society's forthcoming Aeronautic Meeting that will take place at the Bellevue-Stratford Hotel, Philadelphia, Sept. 2 and 3. The meeting, it is believed, will make a tremendous appeal not only to aeronautic engineers but to all persons who wish to obtain the most authentic and uptodate information available with regard to aircraft development. Technical data and illuminating facts of a more general nature will be presented at the meeting by men whose knowledge and experience enable them to speak with authority. Entertainment features and an inspection visit of more than ordinary importance, in addition to the technical sessions, promise to make the Aeronautic Meeting an event that practically every automotive engineer will wish to attend.

Air-Cooled Engines for Aircraft

Three distinguished and authoritative speakers will address the opening session, which will take place on the morning of Thursday, Sept. 2. Progress in the Development of Air-Cooled Engines for Aircraft will be the topic discussed at this session by Commander E. E. Wilson, of the United States Navy; G. J. Mead, of Pratt & Whitney Aircraft Co.; and E. T. Jones, of the Wright Aeronautical Corporation. The speakers will of course view the subject from different angles, and a most informative session is anticipated.

Interesting Papers at Airplane Session

The airplane session, which is scheduled for Thursday afternoon, will be characterized by a certain degree of variety that will undoubtedly be pleasing in its effect. Dr. Adolph Rohrbach, of the Rohrbach Metall-Flugzeugbau, Berlin, Germany, will present important facts in a paper dealing with the topic, Economical and Rapid Production of All-Metal Airplanes and Seaplanes. A feature of the session that will doubtless evoke much discussion will be a number of short talks on the subject, Airplanes for Individual Ownership. Among the speakers who will contribute to the attractiveness of this portion of the program will be E. A. Stinson, of the Stinson Sales Corporation and A. V. Verville, of the Buhl-Verville Aircraft Co.

Bingham at Banquet

Chairman Stout, of the Aeronautic Meeting Committee, is gratified to be able to announce that Senator Hiram Bingham has accepted the Society's invitation to deliver the principal address at the Aeronautic Banquet. In view of Senator Bingham's interest in matters aeronautical and his extensive activities for many years in the aeronautic field, it is especially fitting that he should occupy a place of prominence at the Society's Aeronautic Meeting. During his tenure of office in the United States Senate, Senator Bingham has perhaps been the most outstanding figure in the promotion of Government enterprise in stimulating progress in aviation both within the Government Departments and in the commercial field.

Grover C. Loening, president of Loening Aeronautical Engineering Corporation, has consented to act as toastmaster at the banquet. Mr. Loening is widely known for his very successful career as an aeronautic engineer and for his work as a designer and builder of aircraft.

Application blanks to be filled out by those desiring to attend the Aeronautic Banquet will be included in the *Meetings Bulletin* that will be mailed early in August. In addition to the principal speaker, the members will have the pleasure of hearing short talks from such authorities as E. P. Warner, Assistant Secretary of the Navy, and F. Trubee Davison, Assistant Secretary of War, each in charge of aeronautics in his department. Attractive entertainment features will add to the enjoyableness of the occasion.

AERONAUTIC MEETING

Bellevue-Stratford Hotel **Sept. 2 and 3** **Philadelphia**

Three Technical Sessions!

A Banquet!

A Trip to the Naval Aircraft Factory!

Watch for the next *Meetings Bulletin*

Various Phases of Air Transport

Chairman Stout of the Aeronautic Meeting Committee, who will preside at the session on Friday morning, will open the session by introductory remarks on the need for utilizing satisfactory equipment and methods for successful operation of aircraft. How I Fly at Night will be the subject of an interesting talk by W. L. Smith, of the Air Mail Service; Illumination of Air Routes will be discussed by C. T. Ludington, of the B. B. T. Corporation of America, and H. C. Ritchie, of the General Electric Co.; Directional Radio in Flying will be the timely topic presented by Lieut. L. M. Wolfe and Capt. W. H. Murphy who represent the Army Air Service.

Trip to Naval Aircraft Factory

Through the courtesy of Commander E. E. Wilson, arrangements have been made for an inspection visit to the Naval Aircraft Factory. It is believed that a very large number of those attending the Aeronautic Meeting will avail themselves of the opportunity thus offered. The trip, which is scheduled to take place on Friday afternoon, will be the concluding feature of the Aeronautic Meeting.

J. H. Geisse, chief engineer of the aeronautical engineering laboratory of the Naval Aircraft Factory, who is in charge of arrangements for the inspection trip, is assisted by the following committee: R. W. A. Brewer, N. T. Brown, C. S. Fliedner, J. B. Hill, A. Atwater Kent, H. H. Platt, J. W. Smith, W. J. Swift, Capt. G. C. Westervelt, U. S. N., and Commander E. E. Wilson, U. S. N.

Motorcoaches will convey the members and guests to and from the Naval Aircraft Factory. The visitors will be divided into a number of groups with a committee member assigned to lead each group, and, upon arrival at the factory, the committee members will be assisted by guides in showing the visitors through the plant.

Other Attractions

With the Sesquicentennial celebration in progress and with the National Air Races scheduled to begin on Sept. 4, Philadelphia should prove an ideal site and Sept 2 and 3, most desirable days for the Aeronautic Meeting, and a noteworthy attendance is anticipated. For further details, watch for the two *Meetings Bulletins* that will be mailed during August, one at the beginning, and the other near the middle, of the month.

Local Committees To Cooperate

A. K. Brumbaugh has agreed to serve as chairman of the local committee on entertainment. He will be ably assisted by the following members of the Pennsylvania Section: B. B. Bachman, R. W. A. Brewer, J. H. Geisse, Adolf Gelpke, C. T. Ludington, H. S. Meese, H. F. Pitcairn, and N. G. Shidle.

N. G. Shidle, who will be in charge of the publicity for the meeting, will be assisted in his duties by Athel Denham.

The Housing Committee will be under the able leadership of O. N. Thornton.

E. L. Clark heads the Stunt Committee which comprises the following members: E. A. Corbin, Jr., J. H. Geisse, A. Gelpke, H. S. Meese, A. G. Metz, and Major C. M. Young.

E. W. Templin, chairman of the Pennsylvania Section, is *ex officio* a member of each of the local committees.

PRODUCTION-MEETING PLANS PROGRESS

Interesting Topics Are Scheduled for Discussion in Chicago, Sept. 21 to 23

Four technical sessions devoted to production problems, at least two inspection visits and a stag carnival will be the attractions that will make it difficult for any automotive production man to stay away from Hotel Sherman, Chicago, Sept. 21 to 23. A program of exceptional merit is promised and a large attendance is expected.

Topics at Technical Sessions

Two papers will be presented at the Conveyor Session, each dealing with the design, installation and application of conveyors. Paul Phelps and N. H. Preble, of Mechanical Handling Systems, Inc., are the authors of one of the papers; the other is being prepared by Clarence A. Brock, of the Miller-Hurst Co. A very attractive feature of the Conveyor Session will be the showing of motion pictures as well as stereopticon views to illustrate the points brought out in the papers.

Inspection along the Line is the subject upon which A. H. Frauenthal, of the Chandler Motor Car Co., will speak at the Inspection Session. The latter portion of this session will comprise a symposium at which several inspection men will tell about unknown or little-known inspection gadgets that have proved helpful. The men participating in this

AERONAUTIC MEETING PROGRAM

Bellevue-Stratford Hotel — Sept. 2 and 3 — Philadelphia

Thursday, Sept. 2

10:00 a. m.—Engine Session

- Progress in the Development of Air-Cooled Engines for Aircraft—Commander E. E. Wilson, U. S. N.; G. J. Mead, Pratt & Whitney Aircraft Co., and E. T. Jones, Wright Aeronautical Corporation

1:00 p. m.—Aeronautic Luncheon

2:30 p. m.—Airplane Session

- Economical and Rapid Production of All-Metal Airplanes and Seaplanes—Dr. Adolph Rohrbach, Rohrbach Metall-Flugzeugbau
- Airplanes for Individual Ownership—Short papers by E. A. Stinson, Stinson Sales Corporation; A. V. Verville, Buhl-Verville Aircraft Co., and others.

6:30 p. m.—Aeronautic Banquet

Friday, Sept. 3

10:00 a. m.—Air-Transport Session

- Introductory remarks on the need for utilizing satisfactory equipment and methods for successful operation—W. B. Stout, Stout Metal Airplane Co.
- How I Fly at Night—W. L. Smith, Air Mail Service
- Illumination of Air Routes—C. T. Ludington, B. B. T. Corporation of America, and H. C. Ritchie, General Electric Co.
- Directional Radio in Flying—Capt. W. H. Murphy and Lieut. L. M. Wolfe, Army Air Service

1:00 p. m.—Aeronautic Luncheon

2:30 p. m.—Inspection Trip

- Plant and Equipment of Naval Aircraft Factory

NATIONAL MEETINGS CALENDAR

AERONAUTIC MEETING—Bellevue-Stratford Hotel, Philadelphia—Sept. 2 and 3

PRODUCTION MEETING AND EXPOSITION—Hotel Sherman, Chicago—Sept. 21 to 23

TRANSPORTATION AND SERVICE MEETING—Copley-Plaza Hotel, Boston—Nov. 16 to 18

TRACTOR MEETING—Chicago

ANNUAL DINNER—New York City—January, 1927

ANNUAL MEETING—Detroit—January, 1927

symposium will include A. R. Fors, of the Continental Motors Corporation; P. W. Rhame, of the A. C. Spark Plug Co.; J. B. Scott, of the Yellow Sleeve Valve Engine Works, Inc.; C. S. Stark, of the Packard Motor Car Co., and R. R. Todd, of the Oakland Motor Car Co.

What Goes Wrong with Machine-Tools will be the important question discussed at the Machine-Tool Session by E. R. Stoddard of the Studebaker Corporation of America. O. C. Kavle, consulting engineer, Syracuse, N. Y., will give information on Fitting the Tool to the Job.

The Gear-Production Session will include two papers, one by John Bethune and Walter Hildorf, both of the Reo Motor Car Co., and one by Charles L. Cameron, of the Gould & Eberhardt Co.

Inspection Visits

Arrangements have been made for inspection trips to the Kenosha plant of the Nash Motor Car Co. and to the International Harvester Co. A cordial invitation has also been received from the Yellow Truck & Coach Mfg. Co., affording the members an opportunity to visit its plant.

The Stag Carnival

Taliaferro Milton and his enthusiastic committee have outlined a program for the Stag Carnival, the chief social event of the Production Meeting, that will undoubtedly make that occasion an affair describable only in superlatives.

Cooperation with American Society for Steel Treating

As was the case in 1925, the Production Meeting this year will be held concurrently with the Annual Convention and Steel Exposition of the American Society for Steel Treating, and the two Societies have interchanged invitations to attend the sessions of one another and to take part in the respective social events.

OTHER NATIONAL MEETINGS

Plans Maturing for Transportation and Service Meeting and Tractor Meeting

Two meetings of national scope are scheduled to take place near the end of the current calendar year: the Automotive Transportation and Service Meeting in November and the Tractor Meeting in December.

Transportation and Service Meeting

Motorcoach operation, maintenance, freight handling, construction, and truck operation will be the principal topics discussed at the Transportation and Service Meeting which will convene at the Copley-Plaza Hotel in Boston, Nov. 16 to 18. Chairman J. F. Winchester and his committee have practically completed arrangements for this important gathering which, in addition to technical sessions on the topics above mentioned, will include an inspection trip to the Cambridge maintenance plant of the Standard Oil Co. and a banquet. Prof. W. J. Cunningham, of Harvard University, will be the chief speaker at the banquet, and it is confidently expected that Gov. Alvan T. Fuller of Massachusetts will honor our members by his presence on that occasion.

Tractor Meeting

Two automotive engineering sessions have been planned, by Chairman O. W. Sjogren and his committee, for the Tractor Meeting which will be held at Chicago in cooperation with the American Society of Agricultural Engineers early in December. Four papers of great interest will be presented by men who can speak authoritatively on the topics that they plan to discuss, and a most interesting meeting is promised those who attend.

AUTOMOTIVE RESEARCH

The Society's activities as well as research matters of general interest are presented in this section

HEAD-LAMP ILLUMINATION RESEARCH

Examples of Its Application and Test Equipment Provided by the Society

This Society, in cooperation with the Illuminating Engineering Society and the Bureau of Standards, is making efforts to assist the industry in finding a satisfactory solution of the headlight problem. The carrying out, according to a carefully prepared program, of fundamental research pertaining to that subject is now being arranged for. That car builders should participate in a cooperative research program of this kind is, of course, imperative. As now planned those who will participate will prepare a test car and study such patterns of light distribution as in their opinion would give the best road illumination. These light distributions need not conform at present to any of the existing specifications. They should, however, constitute good driving-lights and be least disturbing to other users of the road. The participants are to be invited to meet at a favorable location for observation and test of the light distributions that they suggest. The committee in charge of this work is to arrange for any other systems deserving consideration aside from those offered by different car builders.

Test Equipment to Be Used

To make this research fundamental and unbiased and to facilitate progress, a suitable test equipment has been designed by a committee of experts. This equipment consists of a bar to be mounted at the front of the car by the user and includes four special head-lamps. Provision is made for mounting them on this bar side by side in such a manner that they can be aimed individually or collectively and the complete bar and lamp assembly can be removed at any time, without disturbing the adjustment of the individual head-lamps, to facilitate photometric measurements. The assembly is shown in Fig. 1.

The head-lamps are shown in detail in Fig. 2. They are provided with horizontal and vertical focusing adjustments, *a* and *b*, for changing the depth and distribution of light in the beam, as well as with double-contact sockets *c* and con-

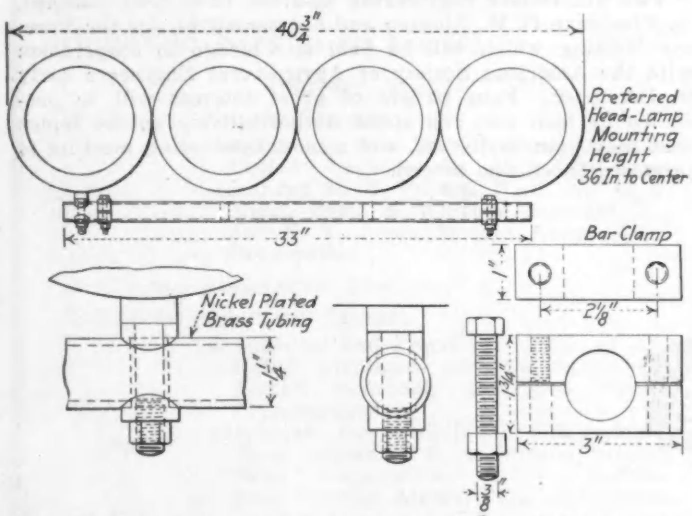

FIG. 1—HEAD-LAMP BAR AND MOUNTING USED IN HEADLIGHTING INVESTIGATION

This Equipment Is Intended To Be Mounted at the Front of the Car and Includes Four Special Head-Lamps That Can Be Aimed Individually or Collectively

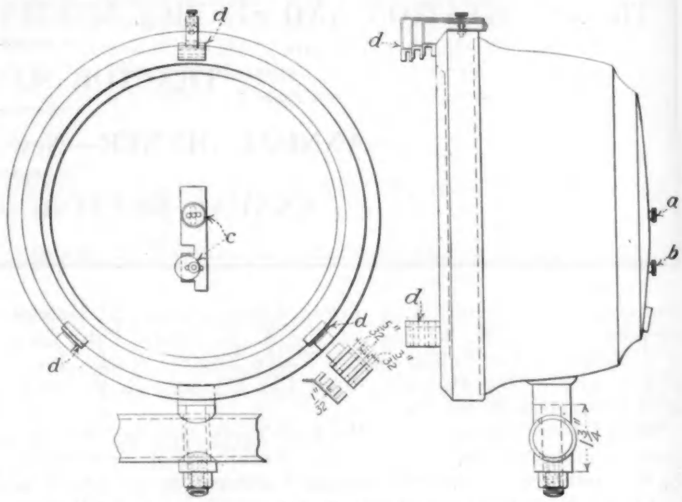

FIG. 2—THE HEAD-LAMPS THAT ARE USED IN CONJUNCTION WITH THE TESTING EQUIPMENT ILLUSTRATED IN FIG. 1

Focusing Adjustments *a* and *b* Are Provided for Changing the Depth and Distribution of the Beam. Either Single or Double-Contact Lamps Can Be Used as a Suitable Socket, *c*, and Connectors Are Provided. A Plain Glass Lens Is Fitted in the Door and Test Lenses and Discs To Give the Desired Horizontal and Vertical Light Distribution Are Mounted in the Bracket *d*. The Lenses Have the Flutes Spaced ¼ In. Apart and Two Can Be Superimposed, if Desired, with the Flutes at Any Angle, Two Slots Being Provided in the Brackets

nectors that will take either single or double-contact lamps. A plain glass is fitted into the regular position in the door and brackets *d* are provided for holding suitable test lenses and discs for distributing the light horizontally and vertically as desired.

A special lens with corrugations spaced ¼ in. apart will be used for spreading the beam in varying amounts. Two such lenses can be superimposed if desired, as slots for holding two lenses have been provided for in brackets *d*. Provision is made for two lenses to permit exact control of the spreading of light vertically, as well as horizontally, if desired. The flutes can be placed at any desired angle.

Fig. 3 shows the three shields that can be used in the outer slot in the brackets *d* (Fig. 2) for changing the depth and distribution of light in the beam. Fig. 4 shows the control box that will be located conveniently near the driver or observer for varying the candlepower from the individual lamps by changing the resistance in the circuit.

Fig. 5 shows the wiring diagram for the equipment. It will be observed that the switching has been designed so as to permit using the equipment, after the cooperative tests are completed, for ordinary head-lamp comparisons. The arrangement is such that two pairs of head-lamps can be mounted on the test car in such a manner that the driver can switch from one to the other under actual operating-conditions and thereby make a direct comparison under the most favorable circumstances.

This drawing also shows an auxiliary driving-light. This will be useful in passing other cars under unfavorable road conditions when the other lamps are aimed so that the light from them does not reach more than 100 ft. ahead of the car. The steering-column switch is such that the auxiliary driving-light is operated from the regular car-battery.

When making observations the four head-lamps will be used in such a manner as to build-up the desired illumination on the road ahead of the car. No one of the beams from the individual head-lamps need, of course, be the same as that

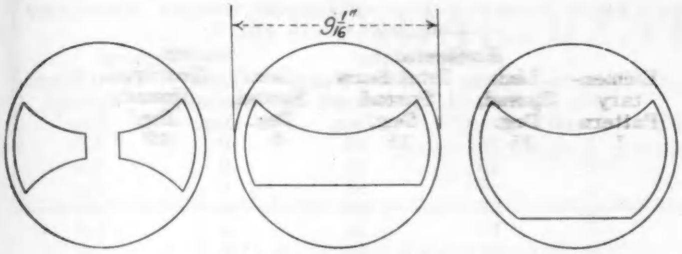

FIG. 3—HEAD-LAMP SHIELD
These Shields Are Intended for Use in the Outer Slot of the Brackets To Change the Depth and Distribution of the Beam

of any other. The distribution will actually be built-up of bands of light of definite width and depth. Several bands of light can be superimposed, overlapped or tilted relative to each other to produce the desired distribution of light. With the facilities provided, it is expected that the user will have no difficulty in obtaining a wide range of patterns of light distribution and in maintaining at the same time satisfactory distribution of illumination on the road. While the car is in motion, the observer can vary the intensity of the light in the individual bands by adjusting the rheostats.

Further details regarding this equipment will gladly be given on request. Those who wish to examine the equipment in detail or to have it demonstrated are invited to communicate with J. H. Hunt, General Motors Corporation Research Laboratories, Detroit.

Application of Test Equipment

This and similar equipments have already been fitted to a number of cars. Some of the interesting results that can be obtained from cars having this equipment were shown in a preliminary demonstration at the Summer Meeting at French Lick Springs, Ind., in June.

The General Motors Corporation provided several cars for these demonstrations, and exhibited the various light distributions that are shown in Fig. 6. The drawings at the upper left illustrate the beam pattern and the light distribution giving a horizontal spread of 50 deg. and a vertical spread of 7 deg. Two head-lamps were used for this purpose. Both lamps were arranged to give identical patterns and the two were then superimposed by adjustment. The approximate candlepower existing over a small zone is 8000. This tapers off to 800 cp. at the outer edge, as illustrated.

The top central group illustrates another light distribution demonstrated by a car of the same company. To obtain this two lamps were used as before. In this case the light distribution is kept within a 32-deg. horizontal spread and a 5-deg. vertical spread. Because of the greater concentration, the candlepower is naturally greater, as is shown. The drawings at the upper right illustrate another beam pattern also obtained from two head-lamps. This is similar to the patterns shown in the upper left and top central groups of drawings, but the light is more concentrated and consequently gives a greater candlepower. The drawings at the

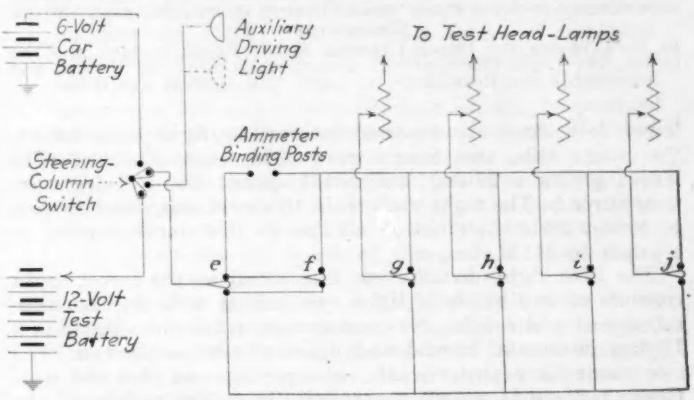

FIG. 5—WIRING DIAGRAM OF THE TEST EQUIPMENT
Switches *e* and *f* Have No Off Position, and Switches *g*, *h*, *i* and *j* Have the Off Position in the Center. The Switching Arrangement Has Been Designed So That the Equipment Can Be Used for Ordinary Head-Lamp Comparisons. The Auxiliary Driving-Light Is Provided for Use in Passing Other Cars under Unfavorable Road Conditions When the Light from the Regular Head-Lamps Does Not Reach More Than 100 Ft. Ahead of the Car

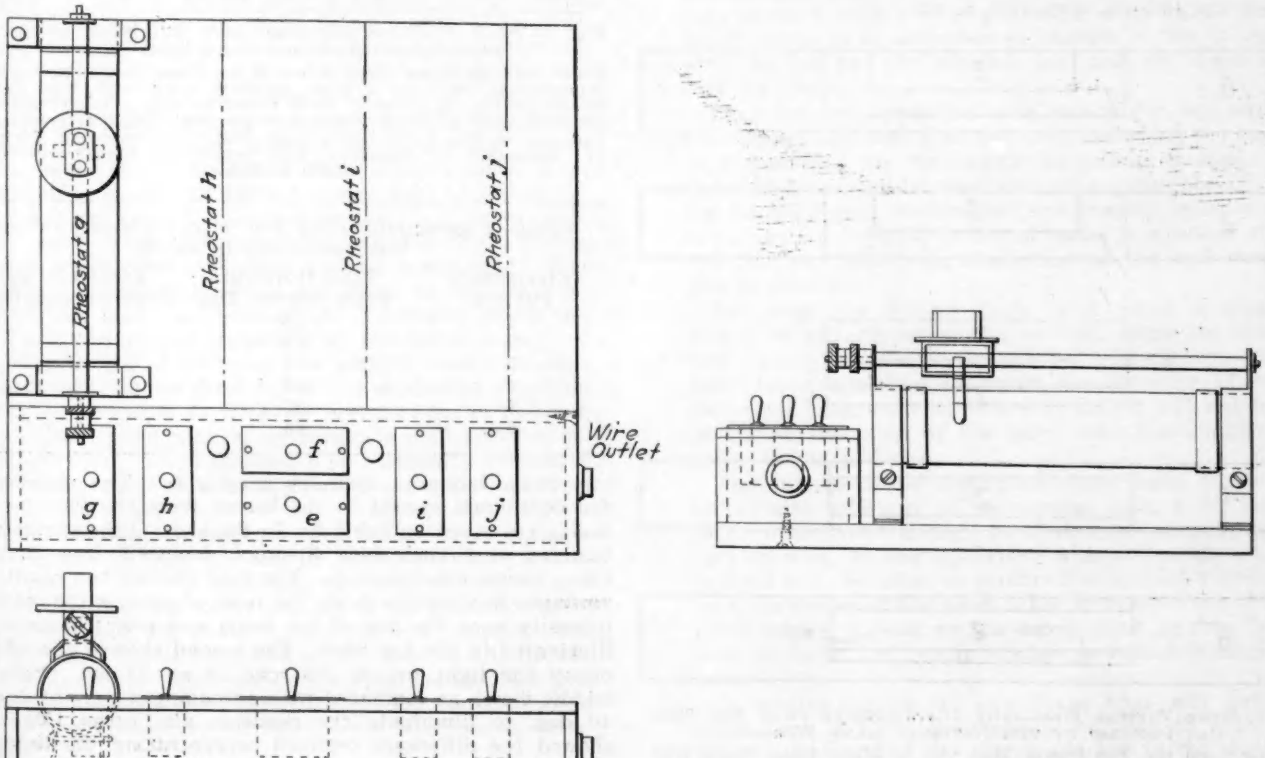

FIG. 4—CONTROL BOX
This Box, Which Is Conveniently Located with Respect to the Driver or the Observer, Enables the Candlepower of the Individual Lamps To Be Varied by Changing the Resistance in the Circuit

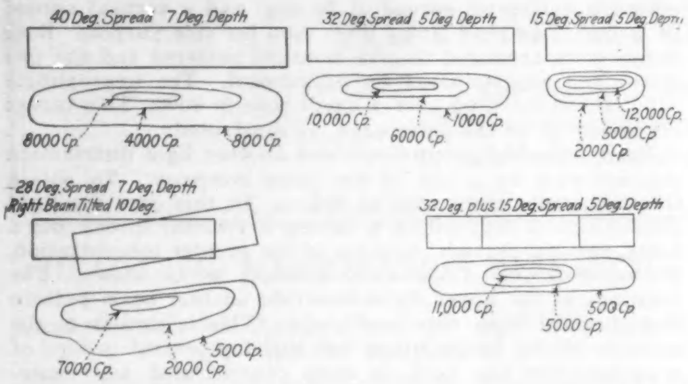

FIG. 6—BEAM PATTERNS AND APPROXIMATE LIGHT DISTRIBUTION CONTOURS OBTAINED FROM FIVE CARS EXHIBITED BY THE GENERAL MOTORS CORPORATION

In Each Group the Upper Drawing Is the Beam Pattern and the Lower, the Light Distribution. Details Regarding the Spread and Depth of the Beam and the Light Distribution Are Given

lower left illustrate another interesting light distribution. To obtain this, two lamps were used, each equipped with lenses giving a 28-deg. horizontal spread and a 7-deg. vertical spread. The right pattern in this case was tilted 10 deg. to give a light distribution similar to that recommended in a paper by H. M. Crane.[1]

The fifth light distribution illustrated at the lower right consists of two bands of light, one having a 32-deg. horizontal spread and a 5-deg. vertical spread, while the other has a 15-deg. horizontal spread and a 5-deg. vertical spread. The two elementary patterns are so superimposed that the narrower pattern is placed symmetrically in the middle of the wider pattern. The candlepower of the resulting beam pattern tapers off from 1000 cp. in the middle to 500 at the edges, as illustrated.

The test car provided by the National Lamp Works was equipped to build-up the beam patterns shown in Fig. 7, and

[1] See THE JOURNAL, May, 1926, p. 468.

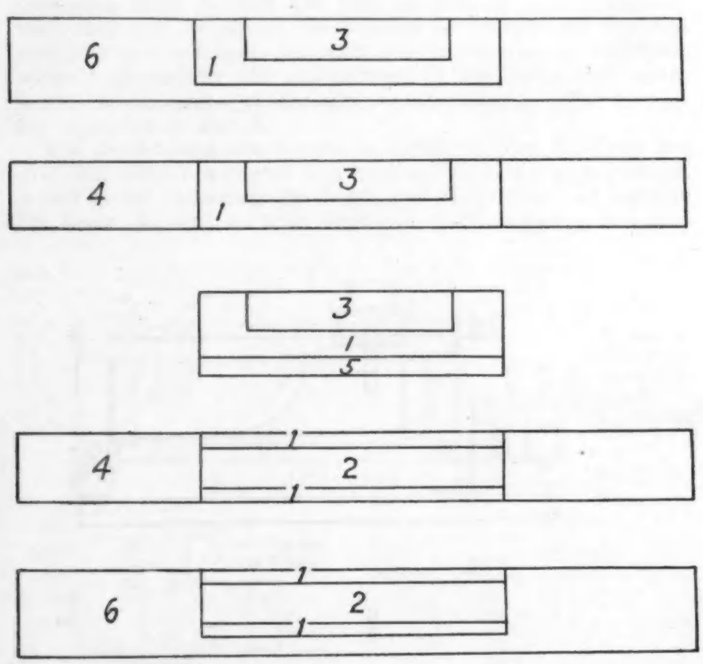

FIG. 7—SOME TYPICAL HEADLIGHT DISTRIBUTIONS FROM THE TEST CAR PROVIDED BY THE NATIONAL LAMP WORKS

Reading from the Top Down, They Are a Wide, Deep Beam with High Intensity at the Top for Uniform Road Illumination; a Wide, Shallow Beam with High Intensity at the Top; a Narrow, Deep Beam with High Intensity at the Top; a Wide, Shallow Beam with High Intensity at the Middle; and a Wide, Deep Beam with High Intensity Slightly below the Top. The Numbers Refer to the Different Elementary Beam Patterns, Details of Which Are Given in Table 1

TABLE 1—DEPTH AND SPREAD OF VARIOUS HEAD-LAMP BEAMS USED IN FIG. 7

	Horizontal		Vertical	
Elementary Pattern	Lens Spread, Deg.	Total Beam Spread, Deg.	Lens Spread, Deg.	Total Beam Spread, Deg.[2]
1	15	18	0	4.0
2	15	18	0	2.5
3	8	12	0	2.5
4	36	40	0	4.0
5	15	18	0	5.0
6	36	40	0	5.0

[2] Variation in vertical spread obtained by manipulation of focusing and use of masks.

to compare their relative values under various road conditions by simply switching from one type of beam to another with the car in motion. The total light emitted from the three head-lamps was approximately the same as that from

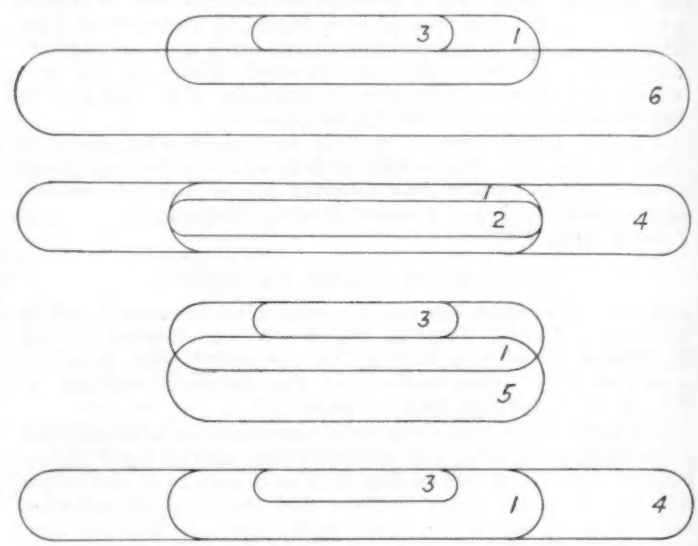

FIG. 8—BEAM PATTERNS OBTAINED FROM THE DEMONSTRATION CAR PROVIDED BY THE GUIDE MOTOR LAMP MFG. CO.

From the Top Down, They Are a Wide, Deep Beam Having a High Intensity at the Top; a Wide, Shallow Beam with High Intensity at the Center; a Narrow, Deep Beam Having a High Intensity at the Top; and a Wide, Shallow Beam with High Intensity at the Top. As in Fig. 7 the Elementary Patterns Composing Each Beam Are Indicated by Numbers, and Details of These Patterns Are Given in Table 2

TABLE 2—SPECIFICATIONS FOR THE ELEMENTARY BEAM PATTERNS USED IN FIG. 8

Elementary Pattern	Total Horizontal Beam Spread, Deg.	Total Vertical Beam Spread, Deg.
1	22	4
2	22	2
3	12	2
4	40	4
5	22	5
6	40	5

two 21-cp. lamps in ordinary headlights. The specifications for depth and spread in the beams from the various head-lamps are given in Table 1. In the short demonstrations attempted at French Lick Springs, emphasis was placed on three simple combinations. The first showed the relative advantages in visibility down the road of placing the maximum intensity near the top of the beam and near the center, as illustrated in the top view. The second showed the effect of piling the light up on the road in an 18-deg. angle (see middle view) as compared with spreading a part of it out to 40 deg. to illuminate the roadside and turns. The third showed the difference between concentrating the beam into a depth of 4 deg. as compared with extending it 2 deg. lower to provide a beam 6 deg. in depth and illuminate the road farther back toward the car.

(*Concluded on p. 164*)

STANDARDIZATION ACTIVITIES

The work of the Divisions and Subdivisions of the S. A. E. Standards Committee and other standards activities are reviewed herein

ROCKWELL HARDNESS-TEST APPROVED

Present S.A.E. Specifications Cover Only Brinell and Shore Hardness-Tests

At the May meeting of the Iron and Steel Division the desirability of including the Rockwell Hardness-Test in the present S.A.E. Recommended Practice for Hardness Tests, which includes the Brinell and Shore methods of testing, was recognized by the approval of a report submitted by the Subdivision on Hardness Tests, consisting of J. H. Nelson, of the Wyman-Gordon Co., chairman; L. A. Danse, of the Cadillac Motor Car Co.; H. L. Greene, of the Willys-Overland Co., and S. P. Rockwell, of the Stanley P. Rockwell Co. The test recommended by the Subdivision follows.

ROCKWELL HARDNESS-TEST

Principle of Test.—The Rockwell tester measures hardness by determining the depth of penetration of a steel ball or diamond cone in the material being tested under certain conditions of load application. In elevating the work to testing position, the machine first applies a preliminary, or minor, load of 10 kg. (22.046 lb.), which clamps and seats the piece being tested and allows the penetrator to break through the light scale and come in contact with the true material beneath. The direct-reading dial is set to zero penetration, directly after due application of the minor load. With the minor load applied and a zero penetration reading known, a final or major load is applied. This forces the penetrator into the metal being tested. The indication at this time on the direct-reading dial comprises not alone the depth of penetration but also the deformation of the testing-machine frame and components, and the work undergoing test. The true Rockwell hardness is read directly from the dial, after removing the major load. This automatically reinstates the 10-kg. (22.046-lb.) minor load and removes the deformation of the machine and part under test. The result is the permanent deformation of the tested metal due to the penetrator and its major load. The Rockwell hardness-readings are based on the depth to which the major load forces the penetrator below the point it was forced previously by the minor load.

Preparation of Surfaces.—A surface similar to that obtained by rough-grinding with a sandstone, carefully cooling the pieces in water to prevent change in hardness due to the heat of grinding, is sufficient for research work. In production it is customary to remove the heavy scale only, as a polished surface is unnecessary.

Thickness of Specimens.—Practically any thickness in excess of 0.020 in. can be tested for comparative hardness. For true hardness, the piece must be of such thickness that the under surface of the specimen, after testing, does not show a point of compression. The minimum possible thickness of any specimen varies according to the hardness, the load applied and the kind of test-point or penetrator used. The hardest steels give true hardness-readings if over 0.027 in. in thickness.

Curved Surfaces.—The true hardness of parts having curved surfaces can be found if the radius of curvature of the surface at the point tested is 3/16 in. If the radius is less than 3/16 in., only comparative results can be obtained. Data for hardness-tests on a highly curved surface should be accompanied by a statement of the radius of curvature. In testing small rounds, the effect of curvature can be eliminated by making a small flat-spot on the specimen.

Rockwell Scales.—Since two loads and two penetrators are used, two scales of hardness are placed on the dial of the machine. The black divisions and the letter C apply when the 120-deg. diamond-cone penetrator and the 150-kg. (330.693-lb.) load are employed. The red divisions and the letter B apply when the 100-kg. (220.462-lb.) load and the 1/16-in. steel-ball penetrator are employed. All data should be prefixed by a letter showing whether the values are on the C or the B scale. Other loads and penetrators can be used, but only comparative results can be obtained. In recording such results all factors relating to them should be clearly stated: the load; the penetrator; the scale used; the thickness of the piece, if very thin; and the curvature of the surface.

Penetrators and Loads.—The Rockwell scale being based on depth measurements, the diamond-cone gives the more accurate readings on hard metals and the steel-ball on soft metals. Hard metals require the 150-kg. (330.693-lb.) load; the diamond-cone penetrator of 120-deg. angle, the point of which is ground spherical by the maker, is the standard Rockwell diamond-cone.

If the readings are below C-25, it is preferable to test the material with the 100-kg. (220.462-lb.) load and the 1/16-in. steel-ball, and use the B scale. Readings on the B scale are not generally taken higher than B-100, when it is advisable to change to the C scale with the 150-kg. (330.693-lb.) load and the diamond-cone test-point.

Each tester is provided with means for regulating the rate of application of the load, for which the standard speed is 5 sec. for production-testing on steel. A speed of 3 sec. can be used without appreciably affecting the readings. Metals that flow readily under pressure, like zinc, should be tested under a specified rate and the duration of the application of the load should also be specified.

Chucking the Work.—Parts with much overhang should be suitably supported so that, when the minor load is applied, the work will be held rigidly. The piece being tested, while under the pressure of only the minor load, must be secure so that it will not tend to tip at the edge of the anvil and move laterally under the major load.

The surface tested should not vary from the horizontal with reference to the vertical axis of the penetrator more than 7½ deg. In testing cylindrical pieces, such as wire, an anvil provided with a V-notch should be used and the point of penetration applied vertically over the center of the piece. The under-surface of the piece, where it rests on the anvil, must be free from scale or burrs that might collapse or flatten during the test.

In testing tubing or any shape that will deform under test, a blunt nose should be used in place of the penetrator, and the test conducted in the regular way to determine if the specimen takes a permanent set, that would invalidate the hardness-test and necessitate consideration of another manner of chucking.

Homogeneity of Metals.—The Rockwell tester measures the hardness of the specimen at the point of pene-

tration, but the reading is also influenced by the hardness of the material under the impression. For example, in testing the hardness of carbon steels, the depth of penetration, when using a diamond-cone and the 150-kg. (330.693-lb.) load, is about 0.027 in., but, if any softer layer is located within 0.027 in. of the impression, the impression will be deeper and the apparent hardness less. Therefore, due regard for this condition must be given when testing material with a superficial hardness, such as a cyanided surface.

Conversion to Other Methods of Hardness-Testing.—Care should be used in converting readings from one method of hardness-testing to another. The factors that cause erroneous conversions are:

Lack of true homogeneity in metals.

Different depths from the surface at which various hardness-tests operate.

Different physical characteristics of various testing devices.

Different properties that are assumed by different metals under cold-working.

No one conversion-table is practical for close conversion on all metals. Tables and formulas have been compiled for some materials that can be used as guides. When conversion is necessary, it is advisable to make such conversion for each particular type of metal and each condition of heat-treatment or mechanical work.

BLACK BAKING-ENAMEL TESTS PROGRESS

Paints, Varnishes and Enamels Subdivision Meets and Inspects Exposure Panels

The Subdivision on Paints, Varnishes and Enamels that was organized under the Passenger-Car Body Division of the Standards Committee has been working for some time on the testing of black baking-enamels to determine the possibility of formulating standard laboratory tests that will give results comparable to the exposure tests which require so much time. A number of the prominent paint manufacturing companies have cooperated enthusiastically by furnishing a quantity of samples of various grades of enamel and in conducting laboratory tests and participating in the exposure tests that are now in progress. Samples of three grades of enamel were furnished by 4 companies and distributed to 11 companies for test, 9 of which have test panels under exposure, making a total of 243 panels on test. The purpose of the test is entirely one of determining to what extent general inspection test specifications can be standardized, especially by purchasers of enamel, and to enable the enamel manufacturers to market their product knowing that their enamels will be tried out on a basis comparable with that of competing companies. All of the samples under test are identified by a code system that is known only to the office of the Society.

The exposure test panels were set out early in June and the Subdivision held its first inspection meeting in Detroit on July 15. The time elapsed was not sufficient to develop any pronounced indications of deterioration in any of the samples on test; all of them on being polished over part of their surface to remove the accumulated grime and dirt showed good luster and no rusting, although indications of surface checking were noted on all samples. The tests will continue until June, 1927, with further inspections of the samples scheduled to be made in September and November, 1926, and June, 1927.

Those present at the meeting in Detroit were Subdivision Chairman W. H. Graves; F. F. Fisher, representing Ralph Ourand; E. C. Fries; J. J. Kroha, representing P. R. Croll; R. J. Moore, representing W. R. Fuller; E. E. Ware, representing J. O. Hasson; R. J. Wirshing, representing H. C. Mougey; G. F. Yott, representing W. N. Davis, and R. S. Burnett. In addition to the Subdivision members and their representatives, R. W. Nye, A. C. Thayer, F. C. Von Wicklen, and H. G. Whitcomb also attended the meeting.

DRAWINGS AND DRAFTING-ROOM PRACTICE

Society To Have Representative on Sectional Committee Now Being Organized

As a result of the preliminary conference held by the American Engineering Standards Committee, of which the Society is a member body, a Sectional Committee is being organized by the American Society of Mechanical Engineers and the Society for the Promotion of Engineering Education, under the procedure of the American Engineering Standards Committee, to formulate national standards for drawings and drafting-room practice. The scope of the committee's project is given as

> The classification of and corresponding nomenclature for drawings in accordance with their purpose; method of representation of the subject, including arrangement of views and sections; use of lines of different kinds and thicknesses; indication of dimensions, tolerances and fits, tapers and slopes, and surface or finish; symbols for elements; indication of materials by cross-hatching; arrangement of border-line, title, part list, notes, changes, and revisions; method of folding and punching; kinds and sizes of lettering, figures and symbols; scales of reduction and enlargement; sizes of drawings and filing cabinets; width of rolls of paper and cloth; size of drafting equipment and tools, and specifications for materials to be used for drawings and drafting.

Probably much can be done with regard to standardizing such items as sizes of drawings and tracings, cross-sectioning and practices that are not governed principally by the requirements of individual firms. A preliminary survey of items included in the scope of the Committee's work indicated in many cases a notable lack of uniformity in practice, standards for which are possible and desirable. The reports of the Committee when formulated and issued should be of widespread interest inasmuch as every manufacturing company will probably be able to adopt at least some recommendations to its advantage.

SOCIETY ACCEPTS JOINT SPONSORSHIP

To Act with Mechanical Engineers and Machine-Tool Builders on Small Tools

The Society, by Council action, has recently accepted joint sponsorship for the Sectional Committee on Small Tools and Machine-Tool Elements that was sponsored and organized by the American Society of Mechanical Engineers and the National Machine-Tool Builders Association under the procedure of the American Engineering Standards Committee, and will soon appoint its representatives thereon. Inasmuch as the work of the Sectional Committee, which is planned on a national scale affecting all machine-tool using industries, will relate directly to that of the Production Division of the Standards Committee, the Society's representatives on the Sectional Committee will be selected from the Division. LeRoy F. Maurer, who is a member of the Division, has been serving for some time as the Society's representative on the Sectional Committee and Subcommittee No. 1 thereof on T-Slots and Parts. The other Subcommittees of the Sectional Committee so far appointed are those on Tool-Holders and Tool-Post Openings and on Machine Tapers.

The Subcommittee on T-Slots and Parts has made a tentative report, copies of which have been sent to the members of the Production Division for criticism. As reports of the Sectional Committee are submitted later on to the sponsors for approval, they will be assigned to the Production Division for consideration and recommendation to the Standards Committee and Society members in the same manner as the Society's regular standards. The tentative report on T-Slots and Parts includes tables of dimensions for T-Slots, Bolts, Nuts, and Cutters and also tables of several modified forms of this type of work-holding construction.

Coincidental Locks

By CHARLES M. MANLY[1] AND C. B. VEAL[2]

BUFFALO AND DETROIT SECTIONS PAPER *Illustrated with* PHOTOGRAPHS AND DRAWINGS

ABSTRACT

AFTER quoting statistics that show the alarming increase in thefts of automobiles and anlayzing numerous conditions under which automobiles are stolen, the authors discuss locks as theft retardants, saying that the providing and the improvement of locks has always been man's method of seeking security from thieves and comes in naturally for first consideration as the normal course to pursue in working toward adequate theft prevention. The present identification systems in use are mentioned, together with their features of advantage and disadvantage, and numerous practices that owners and drivers can adopt which tend to minimize theft are cited. The early forms of locking device are outlined and statistics are included which show the percentage of cars actually locked when they are equipped with a locking device.

The coincidental lock was developed to take advantage of the fact that drivers almost universally turn off the ignition switch when leaving a car unattended, and because this is about the only operation that all drivers can be depended upon to perform. The coincidental lock seeks by one means or another to take the foregoing fact into account by making the locking and the ignition functions interrelated so that it is impossible to open the ignition-circuit switch without either previously or simultaneously locking the car. The standard classification of the Underwriters Laboratories with regard to locks is quoted and commented upon, and the objections to coincidental locks are analyzed.

Popular conceptions of car locking are stated and suggestions made regarding proper procedure for drivers. Desirable and undesirable lock characteristics are enumerated and a list is presented that includes 10 specific rules for judging the effectiveness of automobile locks. An illustrated description of the various types represented among the locks now classified as Group 1 is then presented to bring out the leading constructional and operative characteristics of coincidental locks.

WHATEVER the various opinions may be concerning coincidental locks, and the amount of controversy on this subject during the last several months indicates the existence of a wide difference of opinion, all who have given serious thought to the matter agree that something should and, finally, must be done to reduce the alarming increase in thefts of automobiles and the consequent rapidly mounting insurance rates. A survey of 28 cities for 1924 shows that a total of 57,331 automobiles were stolen. According to these statistics, compiled by the National Automobile Dealers' Association, 10,064 cars were stolen in New York City; 7326, in Los Angeles; 7187, in Detroit; 3440, in St. Louis; 3257, in San Francisco; and so on down the list. For 1925, approximately 7500 cars were stolen in Chicago alone.

From the activities of the National Automobile Underwriters Conference in increasing rates and insisting that something must be done to reduce automobile stealing, all of us must have come to surmise that the theft of cars is truly a serious question with insurance companies. The car owner and the car builder really have just as much interest in this entire question as the insurance companies, but they are certainly not equally aware of the fact. It is true that a majority of stolen cars are recovered, but each joy-ride theft, and such thefts are of considerably more importance than the work of professional thieves, costs the insurance company involved from $50 to $1,000. The insurance company has to put the car back in the condition it was before being stolen, and the owner may untruthfully report that the car was in perfect condition and that the spare tire was new, statements the insurance companies cannot disprove. Often, the car is damaged and abandoned.

The owner of a stolen car is without its use and, if he requires a car for business usage, he must hire it at his own expense and not at the expense of the insurance company. Assuming that the car is recovered, the owner must identify it and then await the insurance company's pleasure regarding the time taken to put it in repair, and experienced owners know that repairs are not usually made in a hurry, since insurance-company repairs are not paid for at rush-job rates. A loss of business time and a wait for his car is the consequent luck of the owner. If the thief is also caught, the owner must not only identify his car but must sign a complaint and he is expected in court. If he does not appear in court, papers forcing him to appear are usually served on him. So, on the average, he is fortunate if he does not lose more than 2 or 3 business days besides losing the use of his car. In many instances the latter case may, in itself, cause a serious business loss. If the car is not recovered, the owner has to wait 60 days for his insurance money. Thus, the car owner pays the bill whether it is his car that is stolen or the other fellow's. It is surprising how little the representatives of most car builders seem to know about relative insurance rates and how completely they fail to appreciate that a low theft-rate for certain cars makes it easier to market them.

The following statement from G. Clark Mather, chief engineer of the Paige-Detroit Motor Car Co., Detroit. shows what the car builder thinks of the owner, and probably all will agree that he is right.

> The automobile owner who fails to utilize the safeguards provided by the builder of his car shares, with the automobile thief, the responsibility for maintaining high insurance-rates.
>
> Owners have but little excuse for leaving their cars unlocked. Strict attention to locking the car, maintained resolutely for just one week, will form a habit, so that it will become second nature to safeguard the car at every stop. It's a good habit to cultivate.

Moral hazard enters as a recognized factor in every insurance risk and automobiles are far from being an exception. A. R. Small, vice-president of the Underwriters Laboratories, fully recognized this in his paper

[1] M.S.A.E.—Consulting engineer, Manly & Veal, New York City.
[2] M.S.A.E.—Consulting engineer, Manly & Veal, New York City.

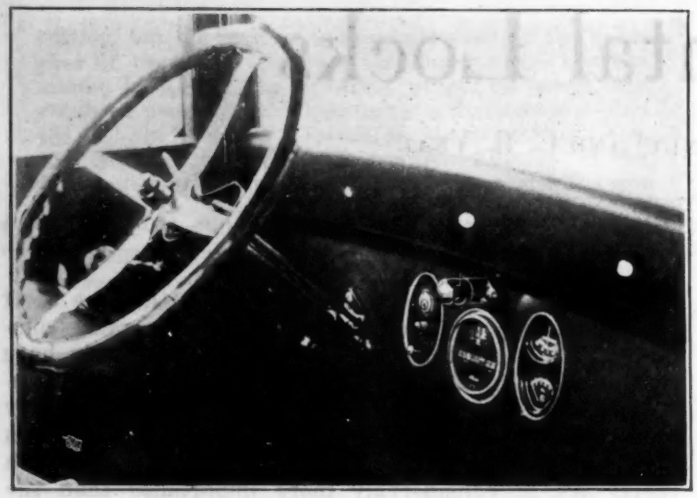

FIG. 1—AN IGNITION-LOCK INSTALLATION
This, the First Lock Approved, Is Shown in the Locked Position. Inserting the Key and Giving It a One-Quarter Turn Releases the Lock. The Cylinder Then Springs Automatically into the Unlocked Position

on Automobile Locking-Device Classification and Theft Insurance[2], in which he said:

> The auomobile-theft problem from the insurance viewpoint includes in its defining lines the following: (*a*) the automobile has become a utility, which is (*b*) generally available and (*c*) readily operated by the public (*d*) without general comment; (*e*) the automobile readily lends itself to illegitimate use by the irresponsible joy-rider, (*f*) to organized theft for profit in the sale of stolen cars, and (*g*) to vicious purposes to which the use of stolen automobiles is secondary. If this be the problem, it appears that features (*a*) to (*d*) will continue to grow with the industry.

From 1918 to 1920 inclusive, years marked by universal price-increases and therefore enhanced values of used cars of nearly 100 per cent, coupled with decreased production and delayed deliveries on account of war conditions, the theft loss-ratio was extremely large. But it does not require an abnormal price-condition to make people careless. Ample insurance-coverage is sufficient to cause the owner to forget or to neglect to lock his car. Owners exist who are hoping that some thief will take a fancy to their car, and the prevalence of these "consent" cases is brought out by the shocking theft-ratio during the month of October each year as compared with other months. In October, many open cars must be stored for the winter and, under such circumstances, insurance comes to be regarded as an investment rather than a protection. So long as car owners have no objection to having their cars stolen, they cannot be looked to for help in solving the problem. About 1921, a number of cars were found in Lake Erie near Buffalo; and they have been found in quarries in Illinois, sticking out of the water in the harbor of New York, in old wells, and in gravel pits. *All* are, invariably, cars reported as stolen. Educating the driving public as a remedy would indeed be a large order.

[2] See TRANSACTIONS, vol. 16, part 2, p. 502.

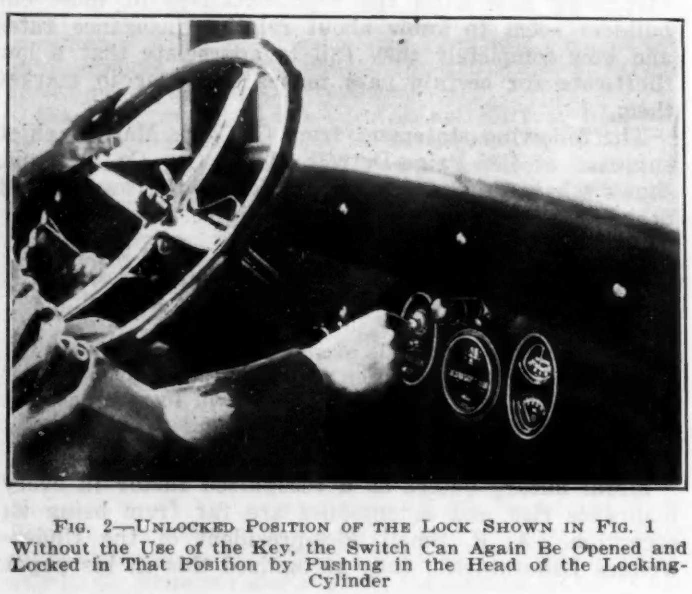

FIG. 2—UNLOCKED POSITION OF THE LOCK SHOWN IN FIG. 1
Without the Use of the Key, the Switch Can Again Be Opened and Locked in That Position by Pushing in the Head of the Locking-Cylinder

LOCKS AS THEFT PREVENTIVES

The providing and improvement of locks has always been man's method of seeking security from thieves and comes in naturally for first consideration as the normal course to pursue in the present instance. Fortunately, as in many other applications of locks, the lock in the case of automobiles does not constitute the only available protective means.

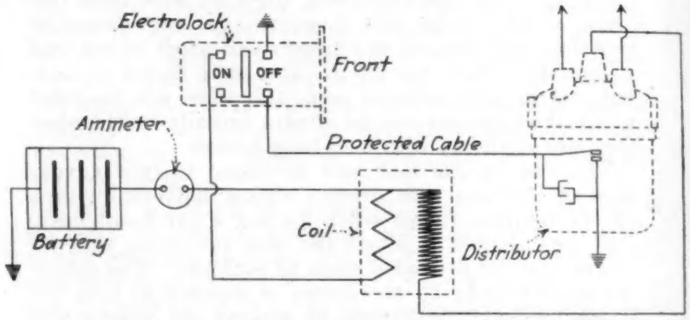

FIG. 3—WIRING DIAGRAM OF THE LOCK SHOWN IN FIG. 1
The Diagram Shows That the Lock-Switch Is Placed in the Circuit between the Coil and the Distributor, Rather Than between the Battery and the Coil. The Wire from the Switch to the Distributor Is Protected by a Flexible Armored Tube

All States have some form of registration requirement, but these laws are by no means uniform. If the registration laws in all States were equal to the best now existing in those States that have gone the farthest in "proof-of-ownership" requirements, much would have been done to frustrate the operations of the professional automobile thief. In most of the States, with but few exceptions, it is easy for the thief to secure license plates to replace the ones rightfully carried by the car he steals. New York City, for example, not only has proved to be a bonanza for the thief but it offers excellent facilities for the operation of stolen cars, since anyone provided with an easily prepared affidavit and $8 can, for the mere asking, obtain license plates for a spurious car and have very few questions asked. Armed with these plates, he is excellently well prepared to disguise from casual observation any stolen car. This practice has become so common in the Metropolitan district that a car bearing a high license-number, clearly of recent issue, can scarcely be driven about the streets without the occupant being subjected to the scrutiny of the detectives of the automobile theft-squad who are quick to notice these new plates in their constant lookout for thieves and stolen cars. There will be a gradual tendency, undoubtedly, toward uniformly good laws affecting registration; but, progress will be slow and, until this Utopian condition is attained and so long as lax regulations obtain in some States, their existence will defeat the purpose of the laws in other States, however effective they may be conceived to be within themselves, and car stealing will continue.

Chassis and Engine Numbering

Much has been said and written and some laws have been spread on the statute books affecting chassis and engine numbering as related to theft. This plan of protection is not without its possibilities and some of the schemes proposed hold promise of effectiveness. As early as 1921, when, in the light of later developments, automobile stealing was in its infancy, the National Automobile Chamber of Commerce, in response to alarm throughout the industry as to the even then large and swelling proportions of this infant profession, referred to the Society the project of evolving some method of marking cars so as to make the changing or disguising of numbers difficult or impossible. Nothing came directly of this request, and it was not until recently that any such system took material commercial form.

All are familiar with a theft-detection numbering-system which, within these last few months, has been adopted as standard equipment by four or more car builders. Through the combination of two metals in a number plate which, by contrasting colors, lend vividness to the serial numerals embossed in an intricate design woven through and over the digits, and by a scheme of locking-screw plugs for fastening the plate to the instrument board and the engine securely, a result is produced which does much to embarrass the thief. He cannot remove the plate without mutilating it or the surface upon which it is secured beyond repair, and, even if he

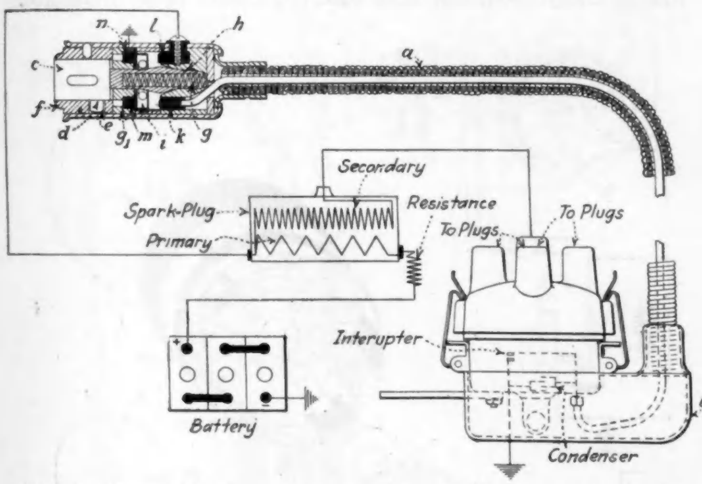

Fig. 4—Entire Mechanism of the Ignition Lock in the Locked Position

The Flexible Tubing Armored with Hardened Steel Is Shown. The Distributor Connections Are Also Enclosed in a Hard-Steel Cup So As To Make Access to These Connections Difficult

did remove it, the absence of the plate would mark the car as stolen property. He is unable to change the numbers or counterfeit the plate successfully, and no opportunity is afforded to purchase a new one. Such a system should go far to vitiate the activities of the professional thief and his allies, the stolen-car dealers and the purchasers.

Another proposed theft-protective numbering-system depends upon "finger-printing" certain distinguishing markings placed on the frame of the car. Together with cross-indexed master-files giving engine and chassis serial numbers, builder's name, year, model, owner's name as shown by the license record, name of present owner and the State or States in which licensed, these finger-print records are designed as aids in the identification of stolen and illicitly abandoned cars. All such detection systems can assist materially the municipal, State and Federal police operators; detective agencies; National Automotive Dealers' Association; and all other agencies,

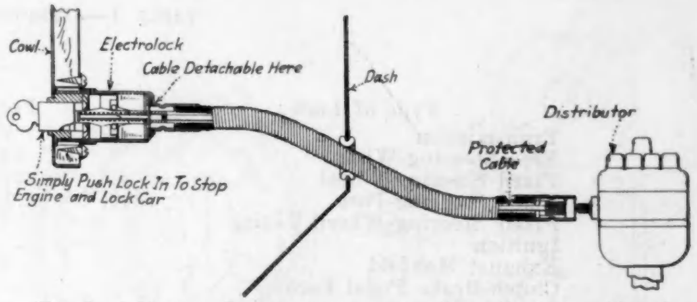

Fig. 5—A Typical Installation of the Lock Shown in Fig. 1

This Lock Consists of a Quick-Acting Switch for Opening the Ignition Circuit, Which Can Be Locked Open. This Lock-Switch Can Be Placed in Any Position Convenient for the Driver. The Ignition Can Be Thrown Off Easily for Coasting or in Emergency without Locking Anything Except the Ignition, But the Key Will Then Be Required To Throw It On Again

public and private, in the apprehension and conviction of thieves and the return of cars to their legitimate owners.

Theft Retardants Available To Owners

The automobile-using public must look to the State law-making bodies for relief so far as registration regulations are concerned, and to car builders for improvement in labeling systems; but there is much that the individual owner-driver can do to improve conditions, assuming that he does not regard his theft insurance as an investment. He can show some judgment in the selection of places and surroundings in which to park his car, using a public garage or reputable parking-station, properly attended, when possible. He can make it a point to see that the parked car is not being molested, especially during the first few minutes after it is parked, because it is then most likely to be stolen. He can beware of the strange boy who solicits the job of watching his car. He can equip his own garage with a burglar alarm. He can refrain from leaving the engine running and, finally, easiest of all, he can lock his car. But his record, en masse, shows that he has not locked his car and, judging the future by the past, he does not intend to do so. Since he does not do this most obvious and easy thing, how can he be expected of his own volition otherwise to guard against theft? All statistics on the subject clearly point to the fact that any locked car,

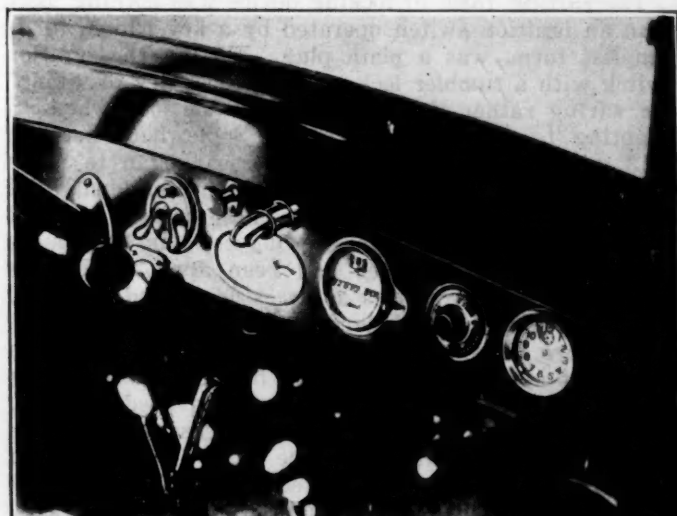

Fig. 6—Another Type of Ignition-Lock Installation

This Lock Is One of the Latest Additions to the Coincidental Group. It Consists Essentially of an Ignition Switch Operated by a Combination Lock of the Disc-Tumbler Type Connected with a Steel Coil-Cover and a Special Distributor-Cap by a Flexible Armored Conduit for the Ignition Wire. The Device between the Clock and the Speedometer Is the Combination Dial of the Lock

TABLE 1—APPROVED LOCKING-DEVICES, 1925

	Number of Locks					
	Accessory					
Type of Lock	Ford	Chevrolet	Other Makes	Total	Standard Equipment	Grand Total
Transmission	2	..	9	11	51	62
Free Steering-Wheel	24	5	11	40	1	41
Fixed Steering-Wheel	27	1	4	32	1	33
Fixed Steering-Post	1	..	1	2	1	3
Fixed Steering-Wheel, Tilting	1	..	1	2	..	2
Ignition	..	..	2	2	..	2
Exhaust Manfold	1	..	..	1	..	1
Clutch-Brake Pedal Lock	..	..	1	1	..	1
Steering-Post	..	..	1	1	..	1
Engine	1	..	..	1	..	1
Total	57	6	30	93	54	147

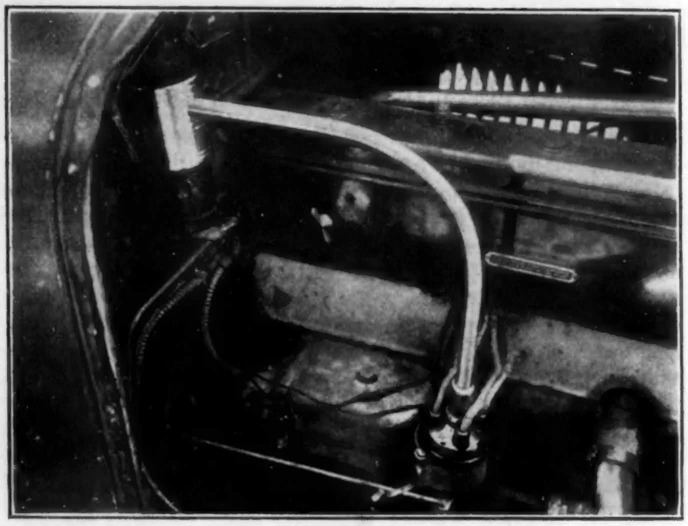

FIG. 7—GENERAL VIEW OF AN INSTALLATION OF THE LOCK ILLUSTRATED IN FIG. 6
The Coil-Cover, the Armored Tube and the Special Distributor-Cap Are Shown Located under the Engine Hood

insurance rates granted for "built-in" locks. While later developments have shown that sufficient experience data were not available to justify the better insurance-rating granted for cars equipped with locks, either accessory or standard, it certainly appeared reasonable at the time to expect that a good lock would act as an effective theft "retardant" on any car and the Underwriters Laboratories counted on nothing more, since, rightly, they have from the beginning consistently emphasized the impossibility of attaining complete "protection or prevention."

While it must be that all approved locks are not equally effective, no preferential rate determined on this basis has actually been put into effect. There is no evidence, if the lock itself has merit, is practically immune from theft.

EARLY FORMS OF LOCKING DEVICE

The earliest form of locking device was nothing more than an ignition switch operated by a key which, in its simplest form, was a plain plug. Fitting the ignition switch with a tumbler lock made it necessary to "jump" the wiring rather than to deal with the lock when attempting to defeat its purpose. Somewhere between 1913 and 1915, automobile-theft losses began to reach serious proportions and, by 1917, the professional thief had a well-organized business. These factors brought forth a perfect deluge of locking devices. In 1921, more than 100 different devices had been approved by the Underwriters Laboratories as accessories, and about 20 locks were offered as standard equipment by car builders. These were classified into 10 types, according to the method of application. Probably because these locking devices did not accomplish what was expected of them, there has been a less noticeable increase in types or number of devices available since 1921. For 1925, the Underwriters Laboratories listed 147 different makes and models of lock, not including coincidental locks, classified into nine types as shown in Table 1.

The increase in the number of companies offering locks as standard equipment cannot be considered to indicate proportional confidence in the effectiveness of locks on the part of these makers, but must be attributed rather to their desire to participate in the preferential theft-

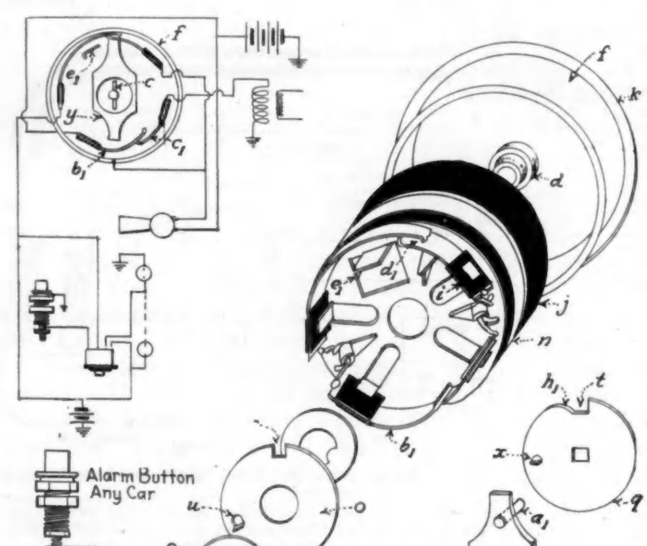

FIG. 8—ELECTRICAL CIRCUITS OF THE LATER TYPE OF IGNITION LOCK
The Electrical Circuits Connected through the Switching Device of the Lock Are Shown, Together with Forward and Rear Views of the Internal Mechanism with the Parts Dismantled but in Relatively Proper Order

however, but that from a business viewpoint the 5 per cent additional credit for built-in locks over that for the "accessory" type has been justified on account of better adaptability to the particular car, superior quality of installation and volume acceptance assured through standardization for the entire production of a given model. As has all too frequently been the case with carefully engineered affairs, the application of the laws of nature to automobile locks was correct; but the laws of human nature were misunderstood and wrongly appraised. The finest lock imaginable is of no avail unless used, and the locks that have been provided have not been used.

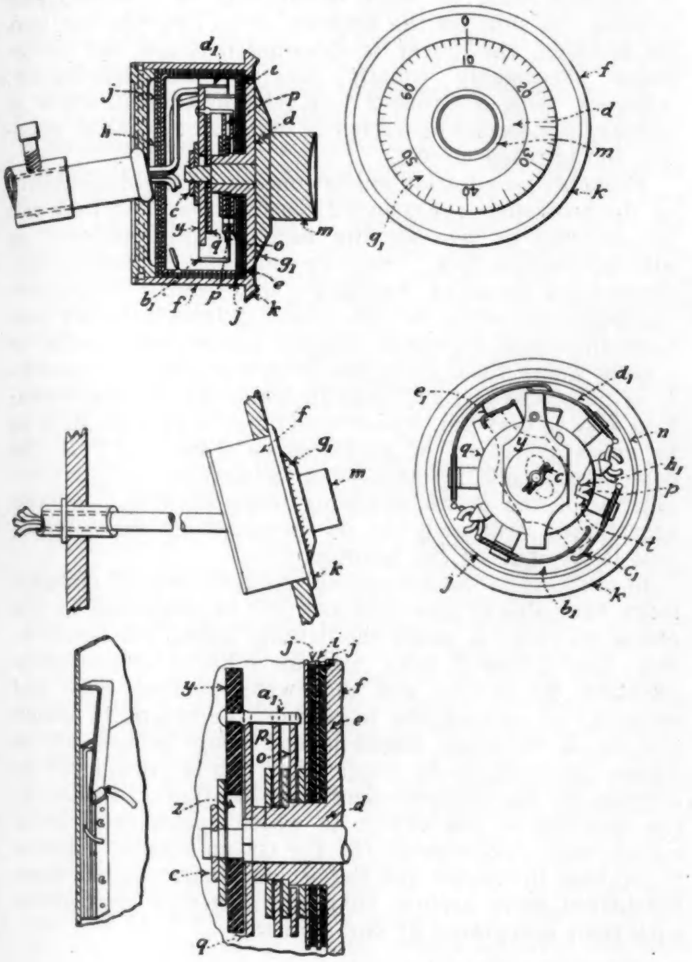

FIG. 9—ACTUATING DIAL OF THE LOCK SHOWN IN FIG. 6
In Addition to the Actuating Dial of This Lock, Assembly and Cross-Sectional Views Are Shown

PERCENTAGES OF CARS LOCKED

A private study undertaken recently by a New York City dealer showed that, out of 100 cars examined, only 30 cars were locked adequately. A similar recent survey on the streets of Buffalo resulted in finding 8 cars locked out of 67 cars examined, all equipped with transmission locks, or only 12 per cent. Of 98 Ford cars equipped with accessory steering-gear locks that were inspected, only 9 cars were found locked, or 9 per cent.

All figures collected by the Underwriters and by other national agencies show that about 85 per cent of cars equipped with approved locking-devices are habitually left unlocked when parked. Since the introduction of locks, the necessity for educating the driving public to use them, if they were to be effective, has been recognized and striven for continuously, but the process has been too slow. Now, it becomes almost imperative that some more direct means be found for combating theft losses.

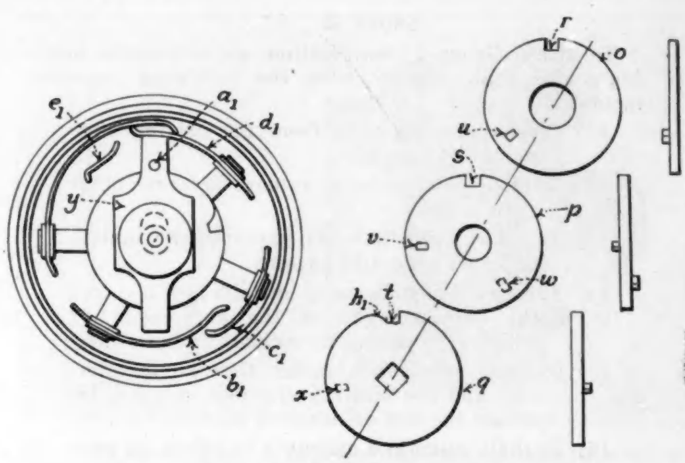

FIG. 10—CONTACT-MAKER IN LOCKED POSITION
In This View of the Later Type of Ignition Lock, the Contact-Maker Is Shown in Locked Position, with the Contact-Springs of the Ignition Terminals Separated, Thus Breaking the Ignition Circuit between the Battery and the Coil and Preventing Operation of the Engine

THE COINCIDENTAL LOCK

The coincidental lock came into being specifically to meet the foregoing situation. Drivers almost universally turn off the ignition switch when leaving a car unattended, and this is about the only operation that all drivers can be depended upon to perform. The coincidental lock seeks by one means or another to take advantage of this fact by making the locking and ignition functions interrelated so that it is impossible to open the ignition-circuit switch without either previously or simultaneously locking the car.

Much confusion and misunderstanding have existed relative to just what constitutes a "coincidental lock" and, since the term appears to have originated with the Underwriters Laboratories and no other representative body has given a clearly expressed definition, we can accept, as properly describing the type, its standard specification for Group 1, representing coincidental locks, which reads as follows:

GROUP 1

> To attain a Group-1 classification, a locking-device shall in addition to meeting the requirements for Group 2, be constructed so that it is necessary to place the locking-mechanism in the locked or theft-resisting position to break the ignition circuit of the automoble and provide methods acceptable to the Laboratories for suitable supervision of installation.

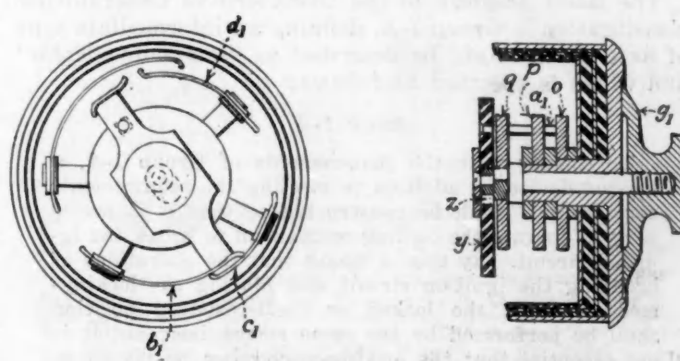

FIG. 11—CONTACT-MAKER IN UNLOCKED POSITION
The Unlocked Position of the Contact-Maker and Other Parts of the Lock Illustrated in Fig. 6 Is Shown

GROUP 2

To attain Group-2 classification, an automobile locking-device shall comply with the following requirements:

(1) It shall be operable from the driving compartment

(2) It shall not consist of removable parts other than a key

(3) If a locking-cylinder is employed, it shall be of listed type and pattern

(4) It shall be sufficiently durable to last for the expected life of the automobile on which it is installed, without undue wear

(5) It shall be of such design that its installation and use on an automobile will not increase the fire or accident hazards

(6) It shall withstand attempts to defeat its purpose for a period of a least 20 min. by a person well informed as to its construction and equipped with tools ordinarily found in a garage

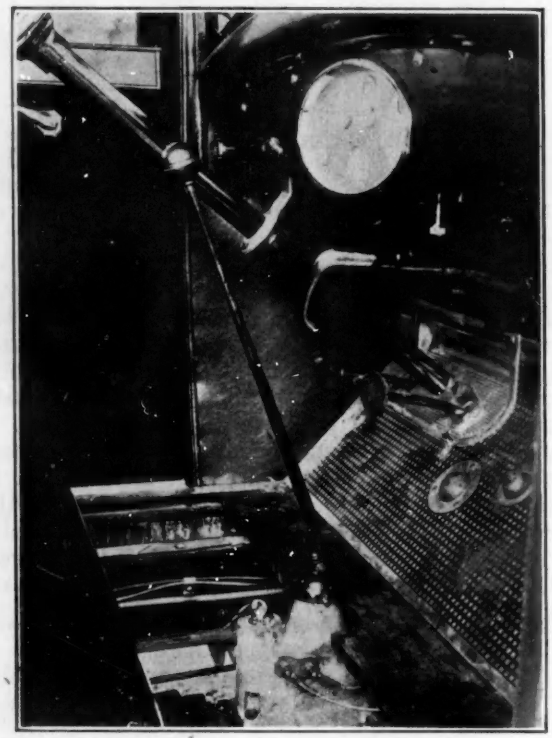

FIG. 12—TRANSMISSION TYPE OF LOCK
No Variety of Lock Has Received as Wide Adoption for Standard Equipment as the Transmission Type. The Lock Shown Is About As Simple a Form of the Transmission Type as Can Be Conceived, with the Coincidental Feature Added

The latest addition to the Underwriters Laboratories' classification is Group 1-*A*, defining an intermediate type of lock which might be described as "semi-coincidental" and which is specified as follows:

GROUP 1-*A*

To comply with the requirements of Group 1-*A*, a locking-device, in addition to meeting the requirements for Group 2 shall be constructed so that it is necessary to operate the locking-mechanism to break the ignition circuit. By this is meant that the operations of breaking the ignition circuit and placing the locking-mechanism in the locked or theft-resisting position shall be performed by the same mechanism; but it is not essential that the locking-mechanism be placed in the theft-resisting position before the ignition circuit is broken. In addition, methods acceptable to the Laboratories for suitable supervision of installation shall be provided

This specification, by explicitly permitting the separation of the ignition control and the locking function insofar as "compulsion to lock" is concerned, appears to put the driver in the same position as he occupied with Group-2 locks. Obviously, he has the same free choice to lock or not to lock in each case, but with the difference that, with a Group 1-*A* lock, the driver cannot turn off the ignition except by the same mechanism which, in another position, performs the locking function. Thus, a decision must be made consciously or unconsciously whether to shut off the ignition or to lock the car and, in deciding, the driver is choosing between two operations presumably equally easy of accomplishment; whereas, with a Group-2 lock, the locking function is distinctly a second operation in addition to that of opening the ignition circuit.

Probably no question exists concerning the desirability of the provisions for Group-2 classification, and they can be accepted as representing fundamental requisites in any automobile lock. Requirement (1) rightfully recognizes the necessity for making any locking device conveniently accessible to the driver. Inaccessibility has been the stock argument against transmission locks as a class where these locks are located at the floor-boards. It is not, however, sufficient to make the locking operation easy to perform. Conditions must be created such as to make avoidance of performance difficult. This the coincidental lock is intended to accomplish without requiring of the driver anything more than he has been accustomed ordinarily to do in stopping the engine; that is, to shut off the ignition.

In addition to the definitional requirements of Group-1 locks, the value of any such lock will be measured by the extent to which it meets the definite individual specifications for Group-2 locks and by other characteristics affecting the builder and the owner, such as ease and certainty of locking and unlocking, the extent to which the car is rendered immobile and many others, all of which, indirectly or by implication, can be considered as covered by the Underwriters' specifications. Probably, the question of the extent to which coincidental locks comply with requirement (5) for Group-2 locks, relative to increase in the fire and the accident hazards, has been considered more serious than any other in connection with their acceptance by the industry.

OBJECTIONS ANALYZED

Objection has been made to those coincidental locks of the steering-gear and transmission types which do not permit shutting off the ignition when coasting down hill, because of increase in the accident hazard through possible increased speed due to continued operation of the engine under these conditions. Added risk from this source is very doubtful; but, on the other hand, no doubt exists regarding the undesirability of coasting with the ignition shut off on account of the attendant crankcase-oil dilution, the collection of carbon and the danger of injury to the muffler from back-fire. So far as control of the car is concerned, the driving hazard should be decreased rather than increased by leaving the ignition circuit closed. A greater accident risk apparently arises through the possibility of accidental opening of the ignition circuit by the device in a moment of excitement or forgetfulness, with those steering-gear locks which provide no means other than the locking mechanism for shutting off engine-power. This hazard will be accentuated if the lock occupies the usual position of the ignition

switch and is operated by turning or pushing, as is common with switches, and it certainly can be diminished, probably to insignificant proportions, by making the locking operation, while still simple and easy, wholly different from that customary for ignition switches. With such an arrangement, opening the circuit will come about intentionally and not as a matter of habit. There are also emergency conditions such as that of the throttle sticking open, or the rather fanciful possibility of a jammed clutch, for instance, which the coincidental lock must meet, without locking the steering-wheel, if the driving hazard is positively not to be increased.

While the insurance companies make no conditions affecting the locking of automobiles in public garages, the individual garage may have its own rules prohibiting locking which will prevent movement or maneuvering of the car within the building or removal in case of fire. With Group-2 locks, the car could simply be left unlocked but, unless some special provision is otherwise made to meet this difficulty, when this same device is made over into a coincidental unit the key will need to be left with the car, both of which procedures are objectionable to the owner who believes in and used his lock.

Much argument has been directed against coincidental locks on the ground that a car so locked cannot be moved by a fire department. Actually, the condition in this regard appears to be no different for Group-1 locks than for Group-2 locks except that, with Group 2, the car *may* be locked while, with Group 1, it *must* be locked if ignition is off. Even a fixed type of steering-wheel lock permits limited fore-and-aft movement of the car in case of necessity.

Statements have been made repeatedly that, in some cities, ordinances exist which prohibit the use of coincidental locks. Among such cities Chicago, Detroit, Buffalo, and Cleveland have been mentioned. According to one statement there are 27 such cities, according to another, 57. Just what the facts are is difficult to determine. The Underwriters Conference reports that its legal department has been unable to find a single instance of any ordinance prohibiting the use of any steering-system lock now listed by the Underwriters Laboratories. On the other hand, there are *many* instances of ordinances requiring that cars *be locked* when left unattended on the public street, and many more prohibiting parking in congested districts. Thus, there are large sections in New York City where it is difficult to find any spot where a car can be parked legally. The same is true in Chicago and, to a less extent, in almost all large cities; but these laws are directed against *parking*, and not against *locking*, and they apply equally to all cars regardless of the presence or absence of locking equipment.

Popular Conceptions of Car Locking

From the fact that shutting off ignition with a coincidental lock also locks the car, some people have the impression that the rule works both ways; that is, if the ignition is interrupted due to short-circuiting or any other cause, or if the engine stalls, the car will thereby become automatically locked. This is not true. The starting-motor has done much to eliminate the hazard of the stalled engine and, in the event of such stalling, the operation of the starting-motor would not be at all affected by the lock.

Where it is necessary to park a car on a grade, it is the practice of many careful drivers to leave the transmission in gear as an aid to the hand brake in preventing the car from rolling down the hill. A coincidental transmission-lock which requires that the transmission

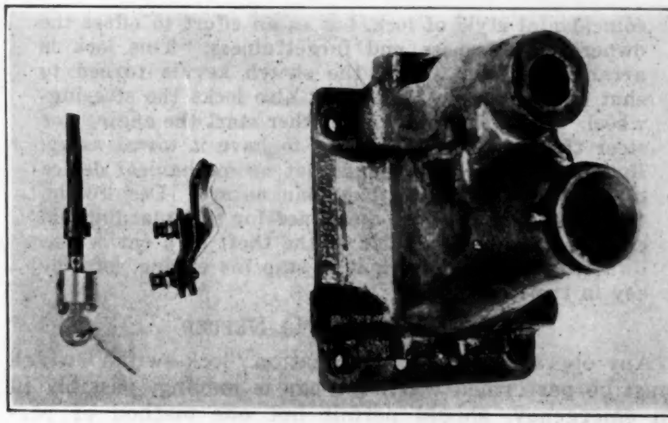

Fig. 13—Three Essential Units of the Transmission Lock Illustrated in Fig. 12
The View Shows the Special Transmission-Cover, the Contact-Spring Assembly and the Lock Proper, with Its Spindle and Cam

be locked in neutral is at a disadvantage in meeting this condition.

While a car protected by any type of coincidental lock cannot proceed under its own power with the lock in the theft-resisting position, that is, while it is no longer "auto-mobile," it is still mobile and, except with the steering-gear type of lock, it can be towed by an enterprising professional thief. If a thief cannot drive a car away under its own power, he attracts less attention on the streets by towing than by spending time in breaking or otherwise defeating the lock. Any notable increase in the number of locked cars can be expected to result in making towing thefts more common, although the practice has long had considerable favor with certain well organized groups of professional thieves.

With all the objections which have been raised against the coincidental lock, it is surprising that so little has been said about the possibility of leaving the key in the lock after the ignition is shut off. The proposed mechanism may force the driver to lock the car "coincidentally" in turning off the ignition, but if he "co-accidentally" or otherwise leaves the key in the lock where has anything been gained? To finish the quotation from Mr. Mather:

> On both Paige and Jewett cars, we have adopted the

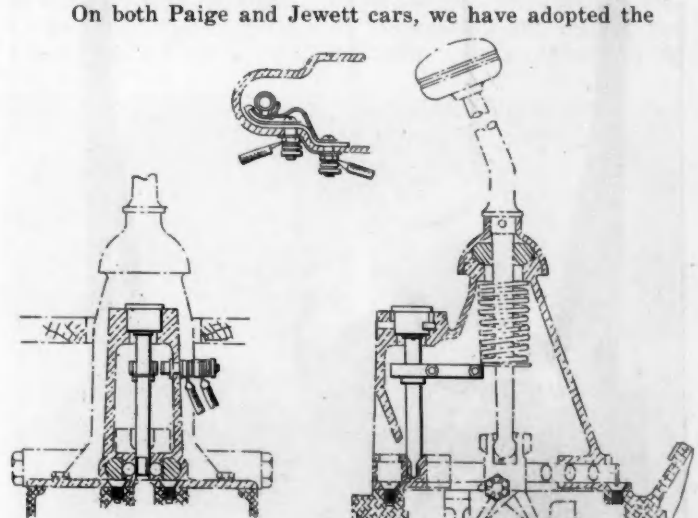

Fig. 14—Transmission-Lock Ignition-Switch
The Ignition Switch for the Type of Lock Illustrated in Fig. 12 Is Shown in the Unlocked or Closed-Circuit Position in the Sectional View at the Top. In Giving the Key a One-Quarter Turn To Lock the Transmission, the Switch Cam Pinned on the Spindle Passes Out of Contact with the Inner Bronze Contact-Spring and Permits the Inner and the Outer Contact-Spring To Separate or Break the Ignition Circuit

coincidental style of lock, but in an effort to offset the owner's carelessness and forgetfulness. This lock is arranged so that, when the switch key is turned to shut off the engine ignition, it also locks the steering-wheel. Then, the thief can neither start the engine nor steer the car if he should try to have it towed away. But already we have found that no mechanical device can adequately cope with human nature. Despite the facilities we have given the owner for safeguarding his car, we have been notified of the theft of a car whose owner, compelled to lock it to stop his engine, left the key in the lock.

HABIT FORMING IS NEEDED

Any operation of the combination "lock-switch" which must be performed when the car is moving, possibly in an emergency, should permit but one method of performance since, even when habit is strong, the one exception will all the more prove at the best troublesome or at the worst disastrous. Where habit can count, one way of doing a thing and one way only is always advantageous, and no driver is a safe driver until habit has rendered his movements instinctive and not studied.

DESIRABLE AND UNDESIRABLE LOCK-CHARACTERISTICS

Assuming that all agree that it is at least desirable that something be done toward decreasing automobile theft and consequently toward securing lower insurance-rates, if the coincidental lock should be considered seriously as a means to that end, and sooner or later it probably will be, it should be determined from the viewpoint of the builder and the owner what characteristics, under the Underwriters Laboratories' specifications, should be avoided as undesirable and what incorporated as beneficial. Having these features in mind an ideal specification might be set up which, while unattainable in its entirety at all times in any one lock, might serve as a hypothetical standard for measuring all coincidental locks.

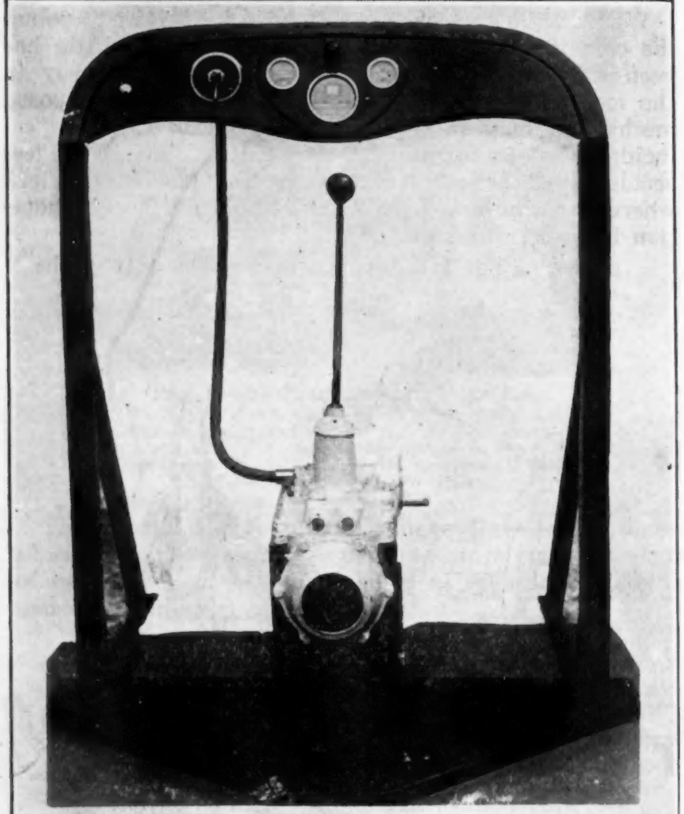

FIG. 15—ANOTHER FORM OF TRANSMISSION LOCK
This Lock Is Designed with the Primary Object of Making It Possible To Move the Lock from Its Usual Position on the Floor-Boards to the Instrument Board or Some Other Equally Convenient Location. It Practically Amounts to "Remote Control" Applied to a Transmission Lock

Accepting the Underwriters Laboratories' rating of locks as theft retardants, the following list, while making no claim for thoroughness, can be considered as a set of rules for judging locks. Any lock fulfilling all these conditions should meet most of the objections that have been raised against coincidental locks.

RULES FOR JUDGING LOCKS

(1) The lock should be conveniently, easily and positively operated, "on" or "off," under all climatic conditions and in darkness as well as in daylight

(2) Either a key should not be required for unlocking or locking should be accomplished only coincidentally with the removal of the key; otherwise, the very purpose of the lock is partly defeated

(3) Slight chance should exist for accidental operation of the lock while the car is in motion

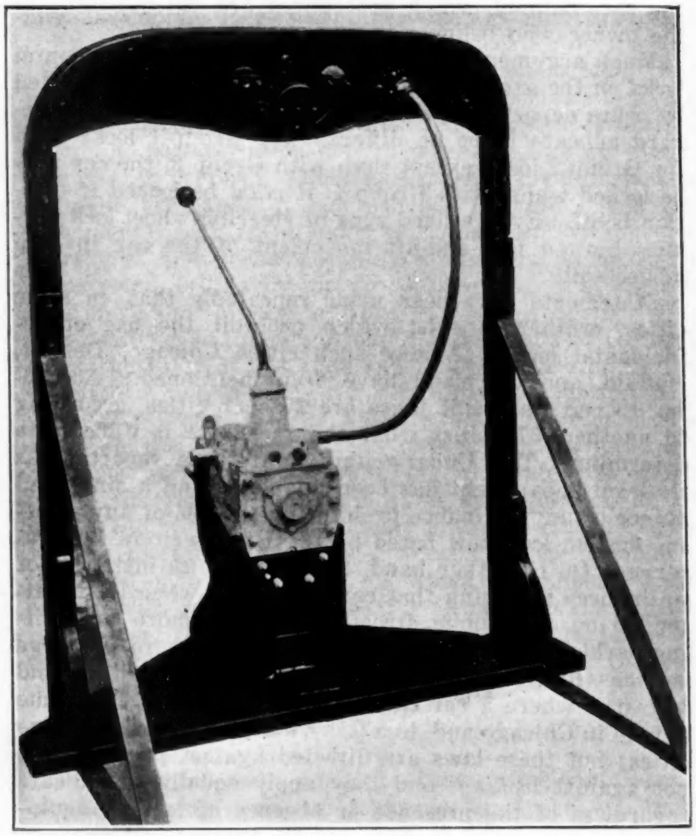

FIG. 16—DUMMY MOUNTING OF THE LOCK SHOWN IN FIG. 15
This Is A Rear View, Showing the Relation of the Instrument Board, the Lock and the Transmission

(4) No lock distinctly similar to the ordinary ignition switch in location and operation should simultaneously lock any control element of the car with breaking the ignition circuit

(5) For quick action in emergency, while the car is in motion, means should be provided for stopping the engine. The means should be simple and easy of operation and such that throwing "on" is the exact reverse of throwing "off" and vice versa

(6) While coasting with the ignition "off" is not to be sanctioned, the driving public still demands some way to shut off the engine when coasting; therefore, a coincidental lock should provide for this, preferably without disturbing the ignition

(7) Movement of the car under certain conditions, as

when left in a public garage or parked in the street, in case of fire, should be permitted with the ignition "off" and without leaving the key with the car

(8) The car should be locked so as to prevent towing

(9) Locking the car should not prevent leaving the transmission in gear when parking on a side hill or cramping the wheels against the curb as desired

(10) The entire lock-mechanism should be simple, rugged, of low cost and easy to install

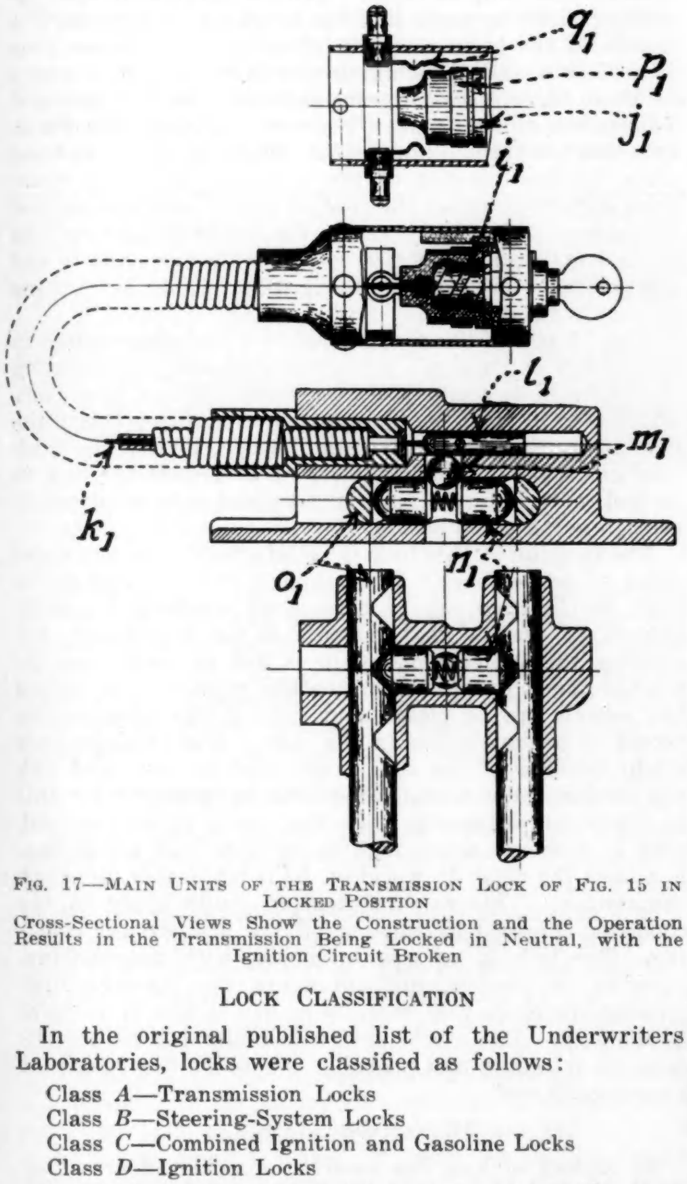

FIG. 17—MAIN UNITS OF THE TRANSMISSION LOCK OF FIG. 15 IN LOCKED POSITION

Cross-Sectional Views Show the Construction and the Operation Results in the Transmission Being Locked in Neutral, with the Ignition Circuit Broken

LOCK CLASSIFICATION

In the original published list of the Underwriters Laboratories, locks were classified as follows:

Class *A*—Transmission Locks
Class *B*—Steering-System Locks
Class *C*—Combined Ignition and Gasoline Locks
Class *D*—Ignition Locks

Inasmuch as the various types are represented among the locks now classified as Group 1, a brief illustrated description of these locks will serve to bring out the leading constructional and operative characteristics of coincidental locks.

VARIOUS TYPES OF LOCK DESCRIBED

The first lock approved was an ignition lock. Many maintain that this is not a coincidental lock because it locks nothing but the ignition. It is the popular notion that the appellation "coincidental" applies specifically because two things are locked, ignition and something else. Fig. 1 shows a view of this lock on the instrument board in the locked position. Inserting the key and giving it a one-quarter turn releases the lock.

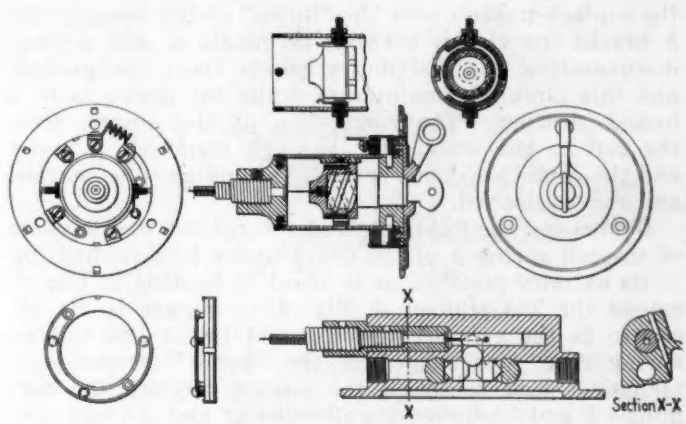

FIG. 18—UNIT ASSEMBLIES OF THE LOCK ILLUSTRATED IN FIG. 15

All the Various Unit Assemblies Are Shown, Including the Instrument-Board Lighting-Switch Integrally Constructed with the Lock-Housing Although Not Essentially a Part of the Coincidental Lock

The cylinder then springs automatically into the unlocked position indicated in Fig. 2. Without the use of the key, the switch can again be opened and locked in that position by pushing in the head of the locking-cylinder.

The wiring diagram in Fig. 3 shows that the lock-switch is placed in the circuit between the coil and the distributor, rather than between the battery and the coil. The wire from the switch to the distributor, as shown in Fig. 4, is protected by flexible tubing *a*, armored with hardened steel. The distributor connections are also enclosed in a hard-steel cup, *b*, so as to make access to these connections difficult. Fig. 4 shows the parts of the entire mechanism in the locked position. Inserting the key in the lock-cylinder *c* and turning the key 90 deg. in a counter-clockwise direction withdraws the lock-plunger *d* from its recess *e* in the locking-cylinder housing *f*, thereby permitting the cam plunger-spring *g* to force the cam-plunger *h* and the cylinder c to their extreme outward or unlocked position as shown in Fig. 2. By this movement of the cam-plunger *h* in Fig. 4, the contact-maker *i*, through the action of the helical-spring ring *j*, shown also in Fig. 5, which rides on the cam surface of the plunger, is made to drop sharply against the two terminals *k* and *l*, thus, through this contact, completing the circuit between the coil and the distributor. This movement of

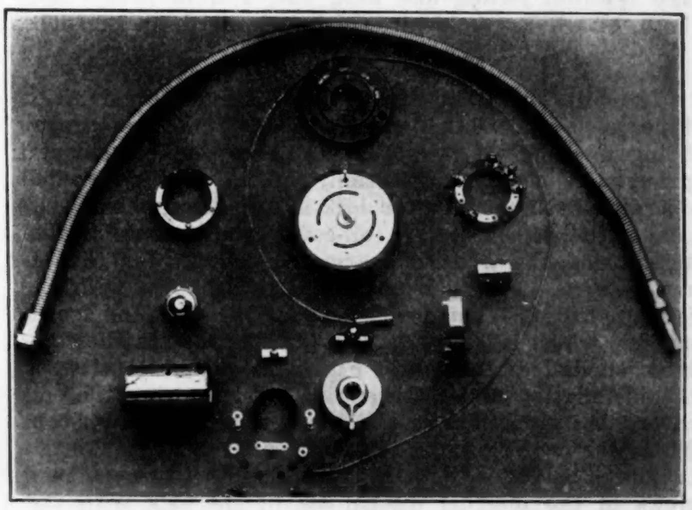

FIG. 19—INDIVIDUAL PARTS OF THE TRANSMISSION LOCK SHOWN IN FIG. 15

The Key of This Lock Cannot Be Removed While in the Unlocked Position

the contact-maker i over the "hump" of the cam-plunger h breaks the circuit between terminals m and n, thus disconnecting the distributor points from the ground, and this circuit is maintained while the device is in a locked position. The completion of the circuit from the coil to the distributor through terminals k and l and the contact-maker i permits the engine to be started and run as desired.

Depressing the locking-cylinder c against the pressure of the coil spring g of the cam-plunger h in its housing to its extreme position, as is about to be done in Fig. 2, causes the lock-plunger d, Fig. 4, to engage in its recess e in the cylinder housing and forces the helical-spring ring j to snap over the "hump" of the cam-plunger h and so break the circuit through the terminals k and l between the distributor and the coil and, by moving down the backward slope of the cam-plunger h, to make contact with the terminals m and n, thereby completing the circuit between the breaker-points and the metal frame of the car, terminal n thus being grounded; hence, all the parts assume the locked positions again, as in Fig. 4.

Fig. 5 shows a typical installation of the lock. From an electrical viewpoint it can be seen that this lock simply consists of a quick-acting switch for opening the ignition circuit, which can be locked open. This lock-switch can be placed in any position convenient for the driver. The ignition can be thrown off easily for coasting or in emergency wthout locking anything except the ignition, but the key will then be required to throw it on again. Accidental opening of the ignition circuit, it seems, is little if any more likely to occur than with any other switch, but a heavily bundled-up driver in winter might find it bothersome with the car under headway to fish out the key from an inaccessible pocket so as to turn the ignition on again once it is off. The car can be left in gear on a grade. A parked car is not rendered immobile in a public garage or on the street, in case of emergency and, for the same reason can be towed freely. The lock can be placed in the theft-resisting position with or without the key being in position; so, there is nothing beyond the fact that the key is required only for unlocking, to prevent leaving the key in the lock when the car is parked unattended. The mechanism is simple and certainly has the appearance of durability. The cost of producing the lock and installing it should not prove burdensome, especially when it is considered as replacing the ignition switch and lock, one, and in many cases both, of which would already be standard equipment.

Another Type of Ignition Lock

The lock shown in Fig. 6, while also of the ignition type, goes to the other extreme as to time of approval, being one of the latest additions to the coincidental group. It consists essentially of an ignition switch operated by a combination lock of the disc-tumbler type connected with a steel coil-cover and a special distributor-cap by a flexible armored conduit for the ignition wire. The instrument board is shown with the lock in position. The device between the clock and speedometer, which looks like a radio tuning dial, is the combination dial of the lock. Fig. 7 is a general view of the installation under the engine hood showing the coil cover, the armored tube and the special distributor-cap. Fig. 8 shows the electrical circuits connected through the switching device of the lock, together with front and rear views of the internal mechanism of the lock with the parts dismantled but in relatively proper order. Attention is called especially to the three operating tumblers o, p and q with their slots r, s and t, and to lugs u, v, w and x respectively; also, to the contact-maker y with its slot z and pin a_1.

Fig. 9 shows the actuating dial, with assembly and cross-sectional views of the lock. The diagrammatic drawing, Fig. 10, shows the contact-maker y in locked position, with the contact-springs b_1 and c_1 of the ignition terminals separated, thus breaking the ignition circuit between the battery and the coil and preventing operation of the engine. Rotating the combination dial to the various numbers indicated in the combination causes the master operating-tumbler keyed to the end of the operating shaft opposite the dial to pick up alternately, by means of the lugs, x, v, w and u, the combination tumbler-discs o and p, bringing the three slots t, s and r of these three discs into alignment so that the spring d_1 pushes the contact-maker y across the shaft, its pin a_1 entering the three aligned slots. With the pin a_1 in these slots, further turning of the actuating dial in a clockwise direction carries the contact-maker into and against its stop e_1, thereby forcing the opposite end of the contact-maker against the spring-contact spring b_1 and compelling it to complete the ignition circuit by making contact with spring c_1.

Fig. 11 shows the contact-maker y and other parts in this unlocked position. A slight rotation of the actuating dial g_1 in the opposite direction causes the cam h_1 of tumbler disc q to push the pin a_1 out of engagement with the disc slots; this upsets the combination, breaks the ignition circuit and causes control of the contact-maker to be lost, after which it can be regained only by properly resetting the combination.

The location of this lock is satisfactory from the viewpoint of convenience. Even though it is a combination lock, the ignition can be thrown off easily and quickly enough to answer that purpose in an emergency, but turning the ignition on again is not so simply accomplished since the full combination must be set before the switch can be closed and setting this combination seems to be impossible in the dark. Even though only slight turning of the dial is required to open and lock the switch, there seems to be little opportunity for this to occur independently while the car is in motion and, even if it should occur, nothing more serious would happen than the delay in working the combination to unlock the switch. This same statement would apply to the condition imposed by turning off the ignition for coasting. The lock in no way interferes with gearshifting, steering or towing, and no doubt the manufacturer stresses the claim that there is no key to lose or to leave in the lock. The whole device is really not as complicated as it seems, and probably can be built strongly at a reasonable cost.

Transmission Lock

No variety of lock has received as wide adoption for standard equipment as the transmission type. Fig. 12 shows about as simple a form of this lock as can be conceived, with the coincidental feature added. Fig. 13 shows the special transmission-cover, the contact-spring assembly and the lock, with its spindle and cam, which constitute the three essential units of the design. From this illustration it will be seen that the device consists of a pin and tumbler lock with a hardened-steel shifting-gate lock-spindle attached by a "tongue and slot" and a riveted pin to the lower end of its lock stem. The other end of this spindle fits between two gate-locking balls which are forced into notches in their respective gate-rods when in the locked position but are allowed by the flattened end of the spindle to recede from these notches when the key is turned to the unlocked position. To this

simple mechanism, which, within itself, constitutes a transmission lock in use for some time on several makes of car, has been added an ignition switch clearly shown in the unlocked or closed-circuit position in the sectional view at the top of Fig. 14. In giving the key a one-quarter turn to lock the transmission, the switch cam pinned on the spindle passes out of contact with the inner bronze contact-spring and permits the inner and the outer contact-springs to separate or break the ignition circuit. Countersunk cap-screws, the heads of which are covered or uncovered according to the position of the shifting rods, secure to the gear-case the special gear-case cover, carrying the lock. As a transmission lock, this device possesses the advantage and disadvantage commonly attributed to such locks of the floor-board type, all of which attributes are too well known to admit of discussion. Considered as a coincidental lock it classifies as Group

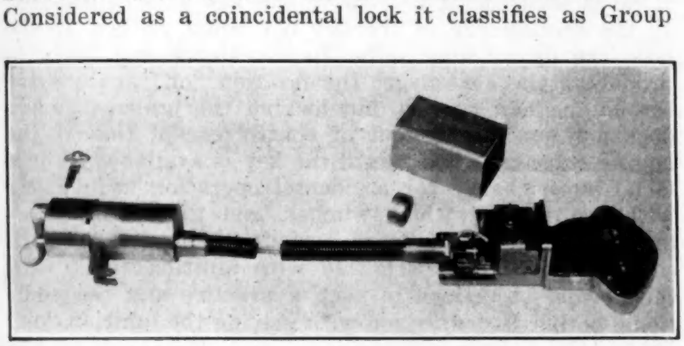

Fig. 20—Lock Control of Intake-Manifold Valve
The Complete Lock-and-Valve-Mechanism Assembly and the Connecting Armored-Tube Are Shown

1, so long as no other means are provided for shutting off the ignition, and the common arguments for and against it again apply. However, owing to the inconvenient location of the lock for operation as the only ignition switch, it seems that it would be preferable to wire it in series with the customary ignition switch on the instrument board, thus lowering its classification.

Another Form of Transmission Lock

Fig. 15 shows another form of transmission lock designed with the primary object of making it possible to move the lock from its usual position on the floor-boards to the instrument board or some other equally convenient location. It practically amounts to "distant control" applied to a transmission lock. Fig. 16 is a rear view of a dummy mounting showing the relations of the instrument board, the lock and the transmission. The construction and operation of the device is brought out better in Fig. 17, which presents cross-sectional views of the main units in the locked position. A three-quarter clockwise turn of the key rotates the male locking-worm i_1 an equal amount which, in turn, drives the female mating locking-nut j_1 forward, rotation of this nut being prevented by a guide on the inside of the lock-housing. The locking-nut, through the plunger wire k_1 enclosed in a flexible armored tube, pushes back the locking-plunger l_1, in the gear-case cover, thereby permitting the locking-ball m_1 to rise and unlock the transmission by freeing the interlocking-plunger n_1 and shifter-rods o_1, thus allowing the gears to be meshed. Simultaneously with this unlocking, the forward movement of the locking-nut brings the switch-contact ring p_1, which is shown at the top of Fig. 17, into engagement with the two switch-fingers q_1, thereby closing the ignition circuit. If the key be returned now to its original position, by turning it counter-clockwise, the locking-nut j_1 will be drawn backward, the locking-plunger l_1 pulled over the ball m_1

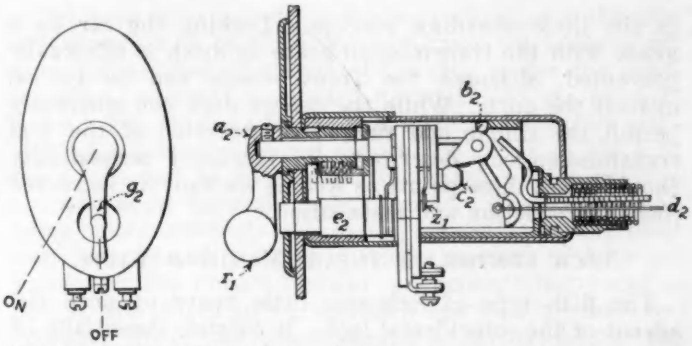

Fig. 21—Locked Position of the Lock Controlling the Intake-Manifold Valve
The Illustration Supplements the Description Given in the Text Regarding Its Operation

by the connecting wire k_1, and all other movement likewise made in the reverse direction, resulting in the transmission being locked in neutral and the ignition circuit broken as shown in Fig. 17. Fig. 18 presents all the various unit assemblies, including the instrument-board lighting-switch integrally constructed with the lock-housing although not essentially a part of the coincidental lock. Fig. 19 shows the individual parts of the complete mechanism.

The key of this lock cannot be removed while in the unlocked position. This coupled with instrument-board mounting should meet the requirements of convenience and accessibility for quick operation, but there is again nothing to assure that the key will not be left in the lock after the ignition is shut off, and the question has been raised as to the ease of operation of this general type of lock, more particularly in cold weather, on account of stiff grease in the gear-case and the frictional resistance of the armored tube. There is little possibility of the device accidentally becoming locked while driving, owing to the fact that it cannot be placed in the locked position, even deliberately without first shifting the transmission-gears into neutral, which within itself, disconnects the engine from the driving axle. On the other hand, this fact makes it impossible to stop the engine in an emergency by a single quick motion in throwing off the ignition. Once it is "off," gear changes must be gone through to get the car under way again. Coasting with ignition "off" is rendered impossible without placing the gears in neutral, which only adds to the hazard of an already bad practice. The locked car can be towed or moved at will, with the lock

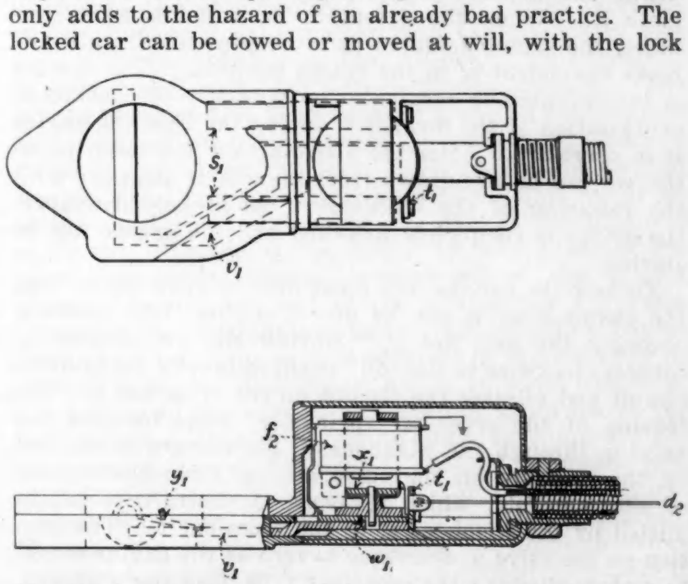

Fig. 22—Locked Position of the Intake-Manifold Valve Lock
This Drawing Is a Continuation of the Description Given in the Text Regarding Its Operation

in the theft-retarding position. Locking the car on a grade with the transmission-gears in mesh is effectually prevented, although the front wheels can be turned against the curb. While the design does not inherently permit the simple and rugged construction of the first transmission-lock described, its increased accessibility should offset these points as well as warrant its increased cost of production and installation.

Lock Control of Intake-Manifold Valve

The fifth type of lock was little heard of until the advent of the coincidental lock. It consists essentially of instrument-board lock-control of a special valve in the intake manifold of the engine. The complete lock-and-valve-mechanism assembly and the connecting armored-tube are shown in Fig. 20.

In the locked positions shown in Figs. 21 and 22, the key has been removed and the switch-lever r_1 has been turned to the "off" position, thereby breaking the ignition circuit and releasing the springs s_1 which operate the cross-bar t_1 in the valve-housing u_1. The recesses in the wishbone v_1 and in the detent plate w_1 are aligned and the spring-actuated armature-detent x_1 is engaged in the aligned recesses. In this position the wishbone v_1 and valve y_1 are secured in the closed or locked position, preventing the operation of the engine.

Moving the switch-lever r_1 clockwise to the "on" position uncovers the key slot, causes the switch-blade z_1 on the inner end of the switch-shaft a_2 to close the ignition circuit and, by the same movement, the hinged bell-crank lever b_2 is raised by the switch-shaft cam c_2. Since the bell-crank lever b_2 and the cross-bar t_1 in the valve-housing u_1 are directly connected by the pull-wire d_2, the above action draws the cross-bar t_1 away from the end of the wishbone v_1 and detent plate w_1 against the action of its springs s_1. The cross-bar t_1 is held in this retarded position during the time the ignition switch is "on." Although the ignition switch is "on," the engine cannot be started because the detent x_1 engages the recess in the wishbone v_1 and holds the valve y_1 in the locked position. Therefore, before the engine can be started, the valve y_1 must be freed. This is done by inserting the key and turning it slightly in the locking-cylinder e_2. This action momentarily energizes the magnet f_2, which withdraws the detent x_1 from the wishbone v_1 and detent plate w_1. When the detent x_1 is raised a given distance, the spring-actuated plate w_1 slips underneath and holds the detent x_1 in the raised position. This feature is incorporated to eliminate the necessity of continuous energization of the magnet f_2 during the time the engine is in operation. After the above action has taken place, the key can be withdrawn from the lock if desired. With the releasing of the wishbone v_1 as already described, the device is completely unlocked and the engine can be started.

To lock the car the key must first be removed so that the switch-lever r_1 can be moved to the "off" position, covering the key slot g_2. Moving the switch-lever r_1 counter-clockwise to the "off" position breaks the ignition circuit and releases the tension on the cross-bar t_1. The tension of the cross-bar springs s_1 tends to close the valve y_1 through the wishbone v_1, but closure is resisted by the pressure on the valve arising from the suction of the manifold, which pressure is contra-wise transmitted by the wishbone v_1 to the cross-bar t_1. The suction on the valve y_1 decreases to zero as the engine comes to a stop, allowing the cross-bar t_1 to push the wishbone v_1 slowly and with it the valve y_1 to the closed position. As the cross-bar t_1 travels forward, it pushes the wishbone v_1 and the detent plate w_1 ahead of it and, at the end of its travel, the recesses in the detent plate w_1 and wishbone v_1 are aligned, thus allowing the detent x_1 to drop into place and thereby securing the mechanism in the locked position.

In general, this lock meets the first requirements of convenient location and easy operation under all conditions, although the dual operations of removing the key and turning the switch-lever are required to shut off the ignition. If the key has been removed from the lock when the unlocking operation was completed, the simple switching movement of the switch-lever will throw the ignition "off" quickly in emergency, but the driver who finds the key still in the lock after attempting to throw off the ignition may find himself in trouble, especially if he is accustomed to remove the key after unlocking. In the contingency of the key not being present in the lock, the driver may suffer inconvenience and delay in producing the key to get the ignition "on" again after the engine has stopped, but locking the ignition switch does not put the car out of control except that if the engine stops it is "off" until the key is available. There is no more chance for accidental operation than exists with ordinary ignition switches, and the consequences are likely to be no more serious than already indicated. Coasting is permitted with ignition "off," with the normal objections to such a practice and the additional bother in connection with getting the ignition "on" again only in case the engine stops. Movement of the car with outside power and towing are freely permitted with locking completed. Locking the car in no way interferes with handling the front wheels or the transmission.

From the foregoing description the conclusion may have been reached that this lock is not simple; illustrations showing all the pieces would complete the evidence that it is made up of a rather alarming number of small parts. This feature naturally raises a question as to its strength, durability and freedom from trouble, although these qualities have been passed upon favorably by the Underwriters Laboratories, and they cannot but add to the production cost.

To obviate complication and its attendant evils the same manufacturer has brought out a simpler and cheaper lock shown in Fig. 23. This lock has a more promising appearance than its predecessor and, while purely mechanical, should be no more difficult to manipulate since the magnetic element in the valve-housing did not assist the mechanical operations performed by the lock-key. This lock shuts off the fuel between the carbureter and the engine by locking a sliding, rather than a rotating, valve in the closed position. It will also be noted that no switch-lever is provided. The key controls the ignition as well as operates the valve; directly rotating the key also completes the ignition circuit by a contact-drum attached to the operating gear on the rear end of the locking-cylinder. After the switch is closed, further rotation of the operating gear through the medium of other gearing pulls a steel wire backward or forward, transferring the same motion to the sliding valve hinged between two steel plates which are secured between the carbureter and intake-manifold flanges. The valve closes the gas passageway when locked and, when unlocked, the valve swings open.

Combination Fixed Steering-Wheel Lock

The lock shown in Fig. 24 is of the combination fixed steering-wheel type with three rings in the combination The device consists of a major assembly, the parts of

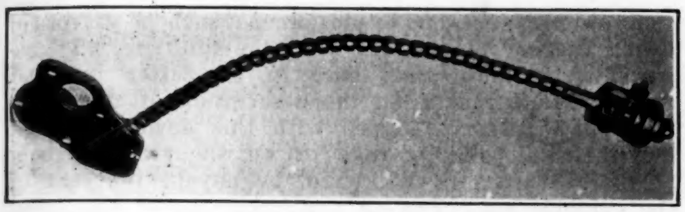

FIG. 23—ANOTHER FORM OF THE LOCK CONTROLLING THE INTAKE-MANIFOLD VALVE
The Lock Shown Is a Simpler and Cheaper One Than That Illustrated in Fig. 20

which are mounted in a cylindrical Bakelite block, as shown in Fig. 25, which serves as the base, and a lock top containing the guiding-bolt. The Bakelite base is pinned securely to the steering-column, while the lock top to which the steering-wheel is pinned is keyed to the steering-post or, in the installation shown, to the standard Ford steering-pinion. Particular features of the parts of this lock are a small slot in the flange of the upper ring, a guiding pin and a slot in the locking-bolt into which the hinged plunger recesses when in the unlocked position.

In Fig. 26 at the right, the device is shown in the locked position in which the guiding-bolt h_2 has been rotated so as to allow the lock-bolt i_2 to engage its recess in the lock top j_2, and the ignition-switch plunger k_2 has been raised free from contact with the ignition terminals l_2. Thus, in this position the locking-bolt i_2 secures the lock top j_2 against rotation, since the lock base m_2 is stationary. Operation of the steering-mechanism is prevented and the ignition circuit is broken.

To unlock the device combination rings n_2, o_2 and p_2 must be rotated to the positions specified in the combination for that particular lock. Placing the top ring n_2 in this position brings the slot q_2 into alignment with the steel pin r_2 protruding from the locking-bolt i_2 and, at the same time, moves the closing plunger s_2 so that the guiding-pin t_2 is partly withdrawn from the locking-bolt i_2 so that neither the flange of the ring n_2 nor the guiding-pin t_2 prevents downward movement of the locking-bolt i_2. The closing plunger s_2 is maintained in this position by a properly shaped slot in the shank of the lock top j_2. It will be noted that this shank of the lock top extends down through the lock base. The middle and lower combination-rings o_2 and p_2 respectively have their cam faces placed together so that the cams of both act jointly on the hinged plunger u_2; hence, when rings o_2 and p_2 are placed in the position specified by the combination, their two cams permit a spring behind the plunger u_2 to force this plunger out from under the locking-bolt i_2, thus completing the release of the ignition-switch plunger k_2 and allowing it to be moved downward in its recess.

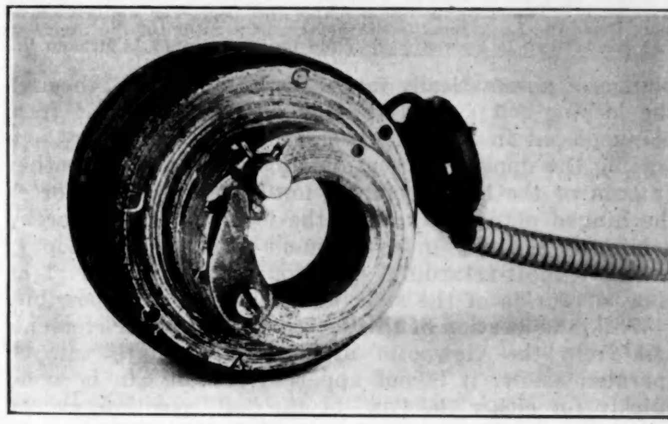

FIG. 25—MOUNTING OF THE LOCK SHOWN IN FIG. 24
The Bakelite Base Is Pinned Securely to the Steering-Column, While the Lock Top to Which the Steering-Wheel Is Pinned Is Keyed to the Steering-Post or, As in the Illustration, to the Standard Ford Steering-Pinion

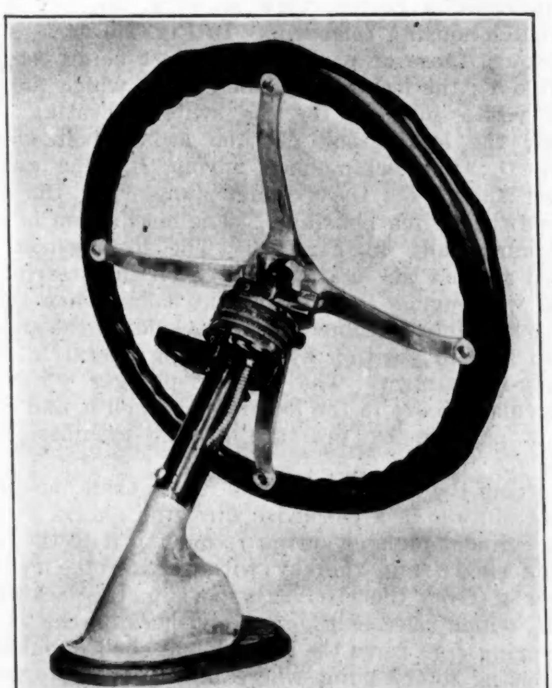

FIG. 24—COMBINATION FIXED STEERING-WHEEL TYPE OF LOCK
The Lock Has Three Rings in the Combination. It Consists of a Major Assembly, the Parts of Which Are Mounted in a Cylindrical Bakelite Block That Serves As a Base, and a Lock Top Containing the Guiding-Bolt

With the combination rings set in the above position, rotation of the guiding-bolt h_2 one-half turn depresses the releasing-block v_2 and through it the locking-bolt i_2 against the presssure of the locking-bolt spring w_2 until the top of the bolt is flush with the top face of the lock base m_2, thereby disengaging the lock top j_2 from the lock base m_2. This action of the locking-bolt i_2 carries downward the guiding-pin t_2 and with it the ignition-switch plunger k_2 into contact with the stationary terminals, thus completing the ignition circuit simultaneously with rendering the steering-mechanism operable. The hinged plunger u_2 is then opposite a slot in the locking-bolt i_2 into which it may recede if forced by the cams of either the middle or the lower combination-ring, so that the combination can be upset by rotating any one or all of the three rings; the upper one causing disalignment of its slot with the locking-bolt pin r_2 and either of the other two rings causing engagement of the hinged plunger u_2 with the slot in the locking-bolt i_2. Thus, upsetting the combination under this condition causes the locking-bolt i_2 to be held securely in the unlocked or driving position. Starting with this unlocked condition, the setting of the correct combination again leaves the locking-bolt i_2 free to be moved—this time upwardly—and rotating the guiding-bolt h_2 one-half revolution permits the locking-bolt spring w_2 to force the bolt i_2 into engagement with its recess in the lock top j_2 thereby, through the guiding-pin t_2, raising the ignition-switch plunger k_2 out of contact with the switch terminals l_2. The locking-bolt i_2 thus assumes the locked position and simultaneously, the action of the spring of the closing

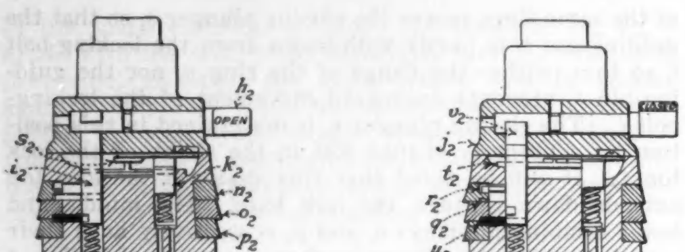

FIG. 26—LOCKED POSITION OF THE COMBINATION FIXED STEERING-WHEEL LOCK

The Guiding-Bolt Has Been Rotated So As To Allow the Lock-Bolt To Engage Its Recess in the Lock Top, and the Ignition-Switch Plunger Has Been Raised Free from Contact with the Ignition Terminals. The Locking-Bolt Secures the Lock Top against Rotation, Since the Lock Base Is Stationary. Operation of the Steering-Mechanism Is Prevented and the Ignition Circuit Is Broken

plunger s_2 automatically forces the guiding-pin t_2 through the locking-bolt i_2, and thereby prevents the bolt from being placed in the unlocked position without first operating the upper combination-ring n_2. Upsetting either or both of the lower combination-rings o_2 and p_2 forces the hinged plunger u_2 under the locking-bolt i_2, thereby holding it securely in engagement with the lock top j_2. In this "theft-retarding" position, shown in the right view, operation of the steering-mechanism is impossible.

While the location of this lock is sufficiently convenient, and from the viewpoint of manual strength can be operated easily, it is not apparent that it can be done quickly for either the "on" or the "off" position, except by one particularly skilled in its use. It is extremely doubtful whether the most skilled manipulator could shut ignition either "off" or "on" in emergency and, supposing that he did succeed in shutting ignition off, he would be in even a worse fix because the steering-wheel would be locked simultaneously. A blind man might be able to work the combination because the numerals are raised on the dials, but it is doubtful whether anyone with fingers of only normal sensitiveness could operate the combination rings in the dark. The chance for accidental operation is certainly nil, and surely no driver is in danger of locking the steering-wheel, due to subconscious operation of what he mistakes to be the ignition switch. No one could accuse such a driver of losing the key or coasting with the ignition "off," assuredly not more than once in the latter instance. It is not apparent from the description of the mechanism how a car equipped with this device could be moved in a public garage or on the street, except straight forward or backward, by anyone ignorant of the combination. Towing and cramping of the front wheels would be prevented when locked, although there would be no interference with any operation of the transmission. For a combination lock the mechanism cannot be considered complicated and, although the Underwriters Laboratories found the present design sufficiently rugged, it appears that the strength of the smaller parts can be increased to advantage.

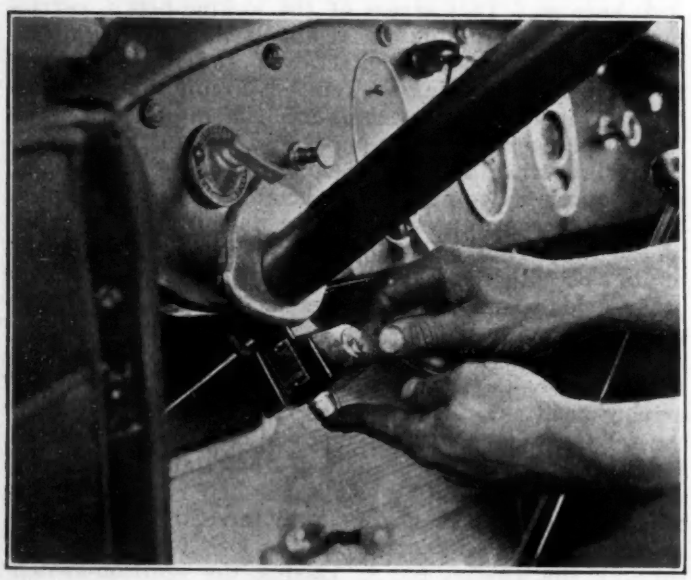

FIG. 27—LOCK OF UNCERTAIN CLASSIFICATION

It Belongs Either in Group 1 or Group 2 and Is Shown in the Unlocked Position. The Two Hands Are Engaged in the Act of Locking. One Hand Holds the Key, While the Other Depresses the Locking-Bolt Shell

LOCK HAVING GROUP-1 AND GROUP-2 FEATURES

The lock shown in Fig. 27 seems to have had a rather checkered career, and it is not certain that we have it classified properly. The Underwriters Laboratories classify it as a Group-1 product, while the manufacturer of the lock says it is not. This difference of opinion apparently can be explained by considering the lock, first as designed and manufactured; as such, it undoubtedly belongs to Group 1 but, when installed by the car builder, as we understand it, an auxiliary ignition switch is wired in series with the switch on the lock, which permits the engine to be stopped by operating the auxiliary switch, thereby giving the lock a Group-2 classification, although it is not possible to start the engine with the car locked.

In Fig. 27 the lock is shown in an unlocked position, the two hands being engaged in the act of locking, one holding the key cramped, while the other depresses the locking-bolt shell. The rectangular switch-housing can be seen just below the label on the lock. Fig. 28 shows, at the left, a top view of the lock in locked position and, at the right, a bottom view showing the switch with the switch-housing removed. In Fig. 29, various parts are shown, those of particular interest being the cylinder-lock A_3; the locking-bolt shell B_3, in which the cylindrical recess opening for the switch-operating pin is visible; the locking-bolt C_3; the locking-bolt yielding-spring D_3; the locking-shell spring E_3; the cylinder-plunger spring F_3; the cylinder-plunger G_3; the switch H_3; and the switch housing I_3. The mechanism is shown diagrammatically in Fig. 30. The locking-bolt c_3 is pressed against the locking-collar j_3 on the steering-tube k_3 and will engage the slot in that collar when the two are brought into alignment, thereby holding the steering-post in a rigid position by preventing operation of the steering-mechanism. The cylinder-plunger g_3 engages the circular groove in the locking-bolt shell b_3 and is held in this position by pressure of the cylinder-plunger spring f_3.

Inserting the key and rotating it less than one-quarter of a revolution in a clockwise direction exerts pressure on the cylinder-plunger spring f_3, moving it to the dotted position shown and thereby withdrawing the cylinder-plunger g_3 from the circular groove in the locking-bolt shell b_3, which releases the shell and permits the locking-shell spring e_3 to force the locking-bolt shell b_3 out of the lock-housing to the point where its travel is stopped by the locking-bolt retaining-pin l_3, which serves also as a guide. The locking-bolt shell b_3 in turn carries the locking-bolt c_3 with it, thus withdrawing the bolt from the locking-collar j_3 attached to the steering-tube k_3, which leaves the steering-mechanism free to be operated as desired.

Fig. 31 shows this now unlocked position of these parts. Simultaneously with the action of the locking-bolt shell b_3 just described, the cylindrical recess on its lower side, by an operating pin, shifts the moving contact in the ignition switch into contact with the ignition terminal-plates, which closes the ignition circuit and allows the engine to be started and run. When pressure is now released on the key, the cylinder-plunger spring f_3 acting against the cam of the cylinder-lock a_3 returns the key to its original position, in which position it can be removed if desired. This action of the cylinder-plunger spring f_3 also returns the cylinder-plunger g_3 to its original position, except that it now projects in front of the locking-bolt shell b_3, thus preventing the locking-bolt shell b_3 from being depressed in the lock-housing and so avoiding the possibility of the device accidentally becoming locked while driving.

To reach the locked position again the key is rotated

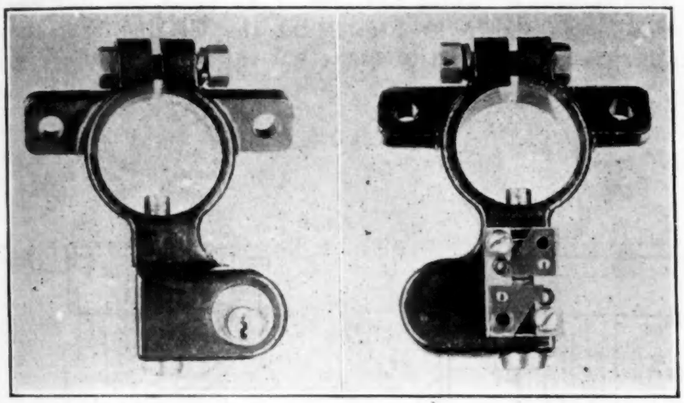

FIG. 28—TWO OTHER VIEWS OF THE LOCK SHOWN IN FIG. 27
At the Left Is a Top View of the Lock in the Locked Position and, at the Right, a Bottom View Showing the Switch with the Switch-Housing Removed

in a clockwise direction, exactly as for unlocking. It will be seen that it is necessary to hold the key in its extreme clockwise position, thus holding the cylinder-plunger g_3 out of engagement with the locking-bolt shell b_3, in order that the locking-bolt shell b_3 can be depressed in the lock-housing. The full depression of the locking-bolt shell b_3 causes the locking-bolt yielding-spring d_3 to force the locking-bolt c_3 against the locking-collar j_3 secured to the steering-tube k_3. With the locking-bolt shell b_3 fully depressed, its cylindrical groove is brought opposite the cylinder-plunger g_3 so that releasing pressure on the key permits the cylinder-plunger spring f_3 to throw the cylinder plunger g_3 into engagement with the circular groove in the locking-bolt shell b_3 and bring the key again to its original position. The slot in the locking-collar j_3 is brought into alignment with the locking-bolt c_3 only when the front wheels of the car are turned directly ahead. When so turned, the locking-bolt yielding-spring d_3 will force the locking-bolt c_3 into the slotted collar j_3. In reverse direction to unlocking, the depression of the locking-bolt shell simultaneously carries the moving switch-contact by its operating pin into the "off" position, thereby breaking the ignition circuit, which brings the lock parts again to the full locked position shown in Fig. 30.

The location of the lock on the instrument board meets every requirement of convenience in that regard, and it permits easy operation except for the somewhat awkward double-movement requirement of returning and holding the key while the lock-switch is pushed into the locked position. The key is required in the lock for both locking and unlocking, but whether it remains in

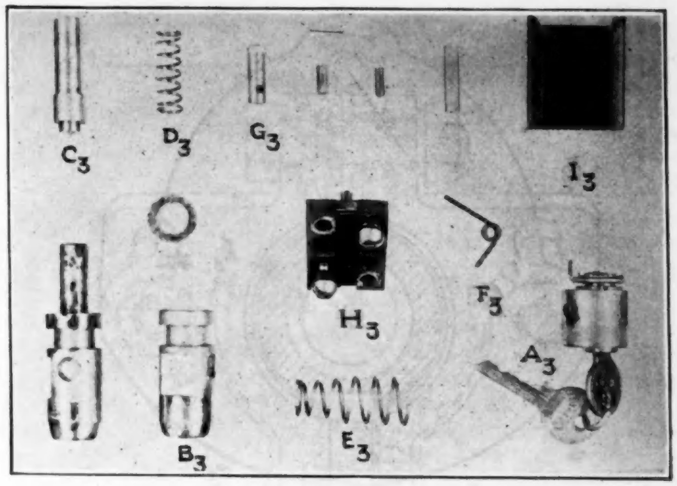

FIG. 29—THE VARIOUS PARTS OF LOCK ILLUSTRATED IN FIG. 27
The Parts of Particular Interest Are the Cylinder-Lock A_3, the Locking-Bolt Shell B_3, the Locking-Bolt C_3, the Locking-Bolt Yielding-Spring D_3, the Locking-Shell Spring E_3, the Cylinder-Plunger Spring F_3, the Cylinder-Plunger G_3, the Switch H_3, and the Switch-Housing I_3. In Fig. 30, Which Is a Diagram of the Mechanism, These Parts Are Indicated by Corresponding Lower-Case Italic Reference Letters

the lock while in the locked or the unlocked position is left optional with the driver. There is really no reasonable possibility of accidental opening of the switch or of locking the steering-mechanism while driving, since the locking-mechanism is effectually locked in the driving position in such a manner as to render the switch operation different from that of the ordinary ignition-switch. For this reason, uniform and dependably quick action in stopping the engine in emergency is out of the question since the key may, or may not, be in position when required and its successful use would result in a locked steering-gear. Coasting with the ignition "off" is not permitted, neither can the car be moved except in a

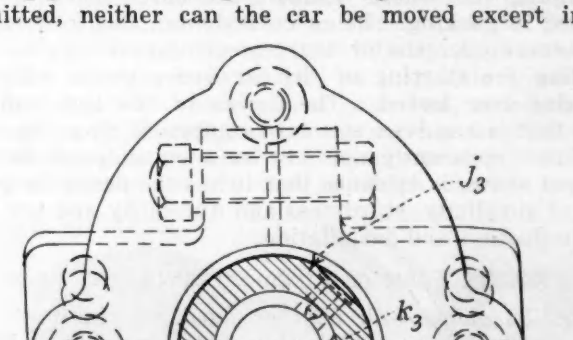

FIG. 30—MECHANISM OF THE LOCK SHOWN IN FIG. 27
The Locking-Bolt c_3 Is Pressed Against the Locking-Collar j_3 on the Steering-Tube k_3 and Will Engage the Slot in That Collar When the Two Are Brought into Alignment, Thereby Holding the Steering-Post in a Rigid Position by Preventing Operation of the Steering-Mechanism

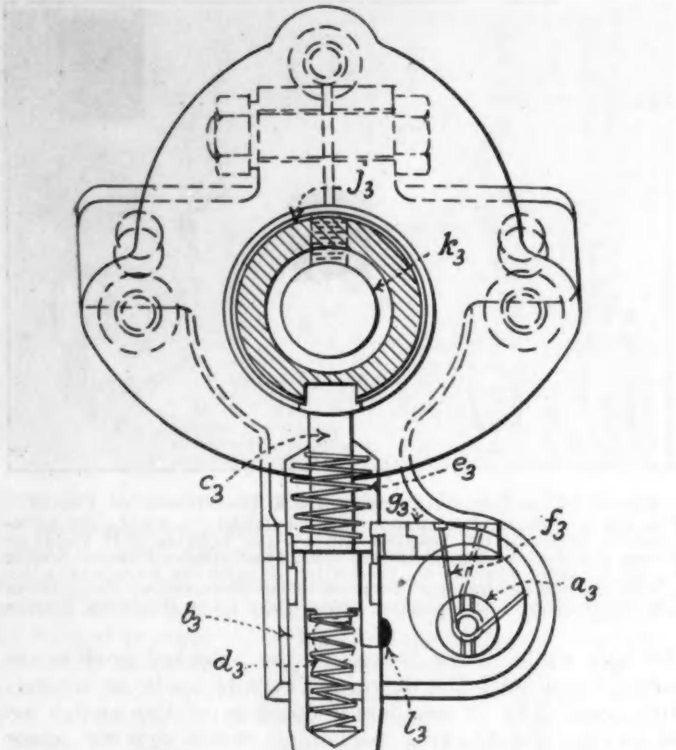

FIG. 31—UNLOCKED POSITION OF THE LOCK ILLUSTRATED IN FIG. 27
A Detailed Description of the Operations of Locking and Unlocking Is Given in the Text

straight fore-and-aft direction, when parked with the engine "off" in a public garage or on the street. Towing is adequately prevented. Leaving the gears in mesh and cramping the wheels against the curb are both permitted in parking. Being coincidental, this lock has an advantage over the ordinary steering-gear lock in preventing the starting of the car under power with the steering-gear locked. The design of the lock and the fact that it has been standard equipment on a few cars, although apparently not now as a coincidental lock as defined above, is evidence that it has the desirable qualities of simplicity, sturdiness and durability and low cost of production and installation.

Another Form of Fixed Steering-Post Lock

Fig. 32 shows still another fixed steering-post lock with the "push-and-pull" button on the instrument board

FIG. 32—FIXED STEERING-POST LOCK
The View Shows Another Type of the Fixed Steering-Post Lock with the "Push-and-Pull" Button on the Instrument Board for Operating the "Gasoline Saver" Furnished with This Lock

at the left of the steering-column for operating the "gasoline saver" or "air-valve" offered as standard equipment with this lock. This portion of the scheme consists of an air-valve controlling an opening into the intake manifold located between the carbureter and the engine whereby, through regulation from the instrument board, a sufficient quantity of air can be admitted quickly and easily to reduce the manifold suction and thin the mixture to a point at which it will cease to fire. Under certain carbureter and manifolding conditions such "gasoline savers" have been found, with small opening, to offer a valuable auxiliary air-adjustment for economical road-operation.

Fig. 33 shows the lock in the locked or "theft-retarding" position. In this position the key can be entered in the slot m_3 and turned in a clockwise direction only, since the cam n_3 prevents the key from being turned counter-clockwise. Turning the key 180 deg. in a clockwise direction causes the cam n_3 to raise the locking-bolt o_3, as shown in Fig. 34 at the left, so that the steering-post is free to turn; but the switch-plunger p_3

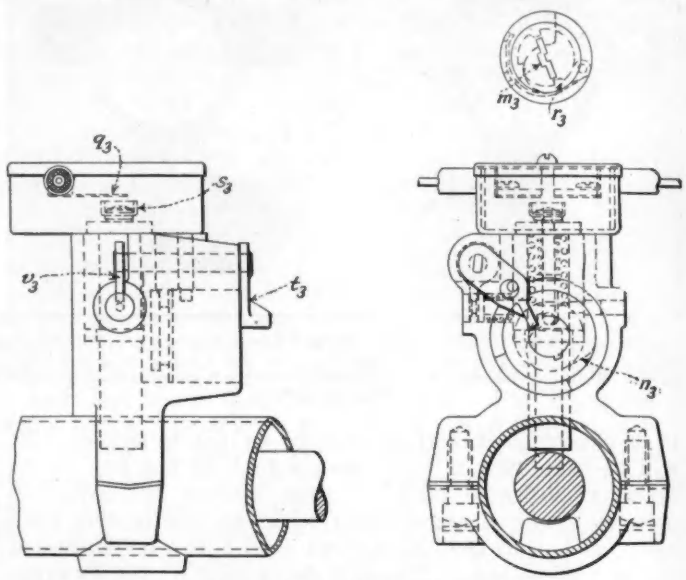

FIG. 33—LOCKED POSITION OF THE FIG. 32 LOCK
In This Position the Key Can Be Entered in the Slot and Turned in a Clockwise Direction Only, Since the Cam Prevents the Key from Being Turned Counter-Clockwise

has not been raised so as to close the ignition switch through the contact-springs q_3. In this 180-deg. position of the key, the dog r_3, in Fig. 33, at the back of the cylinder-lock drops into a notch in its cam and prevents the key from being turned backward, but it can be removed. Removal of the key thus leaves the steering-gear unlocked and the ignition locked "off," which permits free movement of the car when left in a public garage, at a parking station, when shipping the car by boat, or under similar conditions. The position of the lock shown in Fig. 34 is also intended for use when shipping new cars from the factory, when the keys can be forwarded separately.

Turning the key from 180 deg. to 270 deg., as in Fig. 34 at the right, causes the cam n_3 to raise the locking-bolt still higher, which, in turn, raises the switch-plunger p_3 until the brass cup s_3 at its top makes firm contact with the bronze springs q_3, thus closing the ignition circuit. Here again, the dog r_3 at the back of the lock-cylinder drops into another notch and prevents the key from being turned counter-clockwise. The lock is then in the driving position. By turning the key 90 deg. farther forward until the original starting or 360-

deg. position is reached, the shank of the key has been made to pick up the lever t_3 and carry it along, rotating it in the counter-clockwise direction only. At the 360-deg. position of the key, as in Fig. 35, pin u_3 has stopped the lever t_3; thus, the lever t_3 prevents the key from being turned farther in the clockwise direction and the dog r_3 again prevents counter-clockwise turning of the key. This slight counter-clockwise turning of the lever t_3 has also caused the pinion tooth v_3 to push the pin w_3 under the head of the locking-bolt o_3 as shown in Fig. 35; thus, although the cam n_3 no longer holds up the locking-bolt o_3, still it cannot drop and open the ignition switch under the pressure of the main spring x_3 because of the pin w_3 under its head.

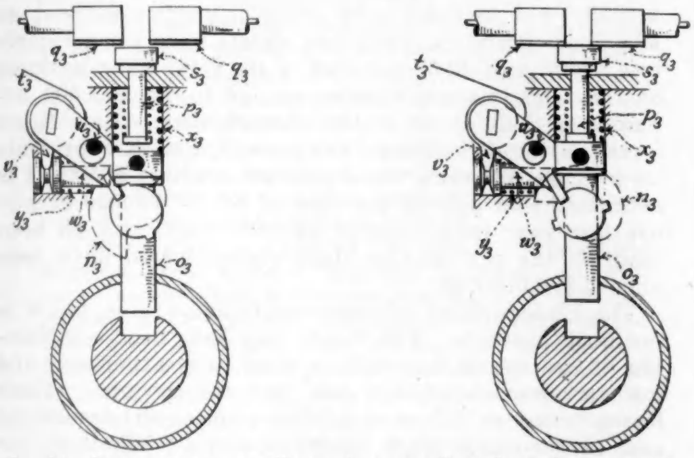

FIG. 34—OPERATION OF THE FIXED STEERING-POST LOCK ILLUSTRATED IN FIG. 32
The Position of the Lock Shown Is Also Intended for Use When Shipping New Cars from the Factory, the Operation of the Lock Being Described in the Text

Although the key has been rotated the full 360 deg., the steering-gear is still unlocked, the ignition is "on" and the key cannot be rotated in either direction; but it can be withdrawn. The withdrawal of the key releases the lever t_3, which, under the influence of the spring y_3 of the pin w_3 is pulled to its original position. This backward movement of the pin w_3 releases the locking-bolt o_3 which, under the pressure of the main spring x_3 is forced into the locked position of Fig. 33. This movement of the locking-bolt releases the switch-plunger, breaking the ignition circuit. The car is then locked, the ignition is "off" and the key is out of the lock. Should the front wheel be turned at an angle when the key is withdrawn, the locking-bolt will stop when it reaches the steering-post, but it has had sufficient movement to break the ignition circuit. The car, therefore, can be left with the front wheels cramped against the curb, just as well as if they were turned straight ahead; but, as soon as the wheels are turned straight ahead, the locking-bolt will register with the recess in the steering-post, as in Fig. 33, and the steering-gear be solidly locked, although the car can still be pushed straight ahead or backward. The ignition cannot be shut off without resulting in that combination; therefore, it is impossible for the driver to forget to remove his key unless he also forgets to stop his engine. Fig. 36 shows the lock-housing and the unit assemblies of the lock.

With the addition of one more "position" or stopping-point, and very slight changes in construction, this lock is also put out so as to receive a Group-1*A* classification. When manufactured for this classification, the mechanism at the starting and the 180-deg. positions functions just as for the Group-1 lock, described in the foregoing text, but an additional stop is placed at about

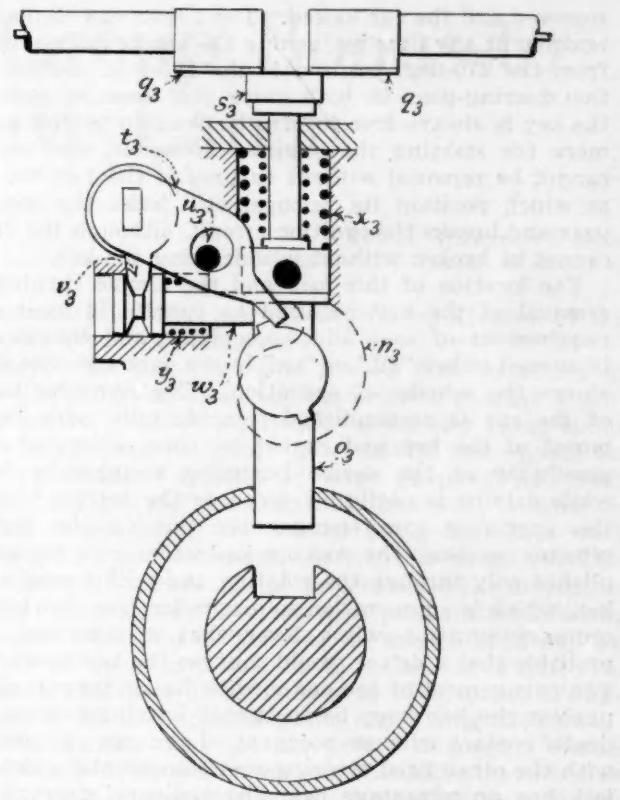

FIG. 35—OTHER OPERATING FEATURES OF THE LOCK SHOWN IN FIG. 32
Additional Details That Are Enumerated in the Text Are Illustrated

195 deg. of rotation. At this point the ignition circuit is still broken and the steering-gear is unlocked. The dog r_3 (Fig. 33) does not permit the key to be turned backward or counter-clockwise; neither can the key be removed. For the 270 and the 360-deg. positions, the notch for the dog r_3 is omitted so that from these two positions the key can be turned backward, although the 270-deg. position still remains the driving position with the steering-gear unlocked and the ignition "on," and the 360-deg. position is still that in which the key can be

FIG. 36—PARTS OF THE LOCK ILLUSTRATED IN FIG. 32
The View Shows the Lock-Housing and the Unit Assemblies

removed and the car locked. The driver can shut off the ignition at any time by turning the key counter-clockwise from the 270-deg. position to the 195-deg. position, and the steering-gear in both cases still remains unlocked; the key is always free to turn back again to 270 deg., or more for starting the engine. However, the key still cannot be removed without turning it the full 360 deg., at which position its removal still locks the steering-gear and breaks the ignition circuit, although the circuit cannot be broken without withdrawing the key.

The location of this lock and the simple turning and removal of the key required to operate it meet every requirement of ease and convenience and the lock can be turned either "off" or "on" in the dark once the driver knows the scheme of operation. The complete locking of the car is accomplished coincidentally with the removal of the key and cannot be done otherwise. The possibility of the device becoming accidentally locked while driving is negligible, since, in the driving position, the operating cam engages the pin on the locking-plunger so that the locking operation can be accomplished only through the rotation and withdrawal of the key, which is an operation so dissimilar from working an ordinary ignition-switch lever that it does not seem probable that a driver would confuse the two operations. The engagement of the dog r_3 with its rachet-cam should prevent the key from being turned by vibration or accidental contact with an occupant of the car. In common with the other fixed steering-post coincidental locks, this lock has an advantage over the ordinary steering-gear lock in that it prevents the starting of the engine and the car with the steering-system locked. The gasoline-saver air-valve furnishes a requisite method for stopping and again permitting a start of the engine, quickly and easily, in an emergency. Notwithstanding the attendant consequences of the bad practice of stopping the engine when coasting, the air-valve should satisfy those drivers who insist on doing it in descending long grades; at the same time, the fact that the ignition is "on" obviates troubles arising from the pumping of fuel while the ignition is "off." Unexploded fuel is not drawn into the cylinder and the drawing-in of a cool air-charge may even be a benefit if, as frequently is the case, the engine has just previously been heated through a heavy climb. With the car fully locked towing is prevented, although complete provision is made for locking the ignition only so that, when desired, the car can be left in a public garage or at a parking station with the full possibility of free movement, without leaving the key with the car. The lock in no way interferes with the operation of the transmission and locking is equally effective whether the front wheels are cramped or left in the straight-ahead position. Examination of the lock indicates that it has about the usual number of parts, all of which can be given any required strength, and the lock can be produced and installed at a fair cost.

SUMMARY

After having circumnavigated this subject, we find ourselves right back where we started. *The Accelerator* of April, 1926, published by the Boston and Old Colony Insurance Companies, states that

> Approximately 250,000 motor vehicles were stolen in the United States during the year 1925, indicating that car theft is keeping pace with motor-vehicle registration. These figures are based on an inquiry covering 41 cities made by the research division of the American Automobile Association. The money value of this wholesale loot was $218,000,000. This value is based on an average price of $875 apiece for used cars, which is the basis applied by the Department of Justice in administering the national motor-vehicle-theft act. Assuming that the average recovery for the Country as a whole was around 80 per cent, the research division of the American Automobile Association places the dead loss to motorists at $35,000,000. The figure would be nearer $50,000,000, it is pointed out, if stolen-car equipment such as tires and parts is included.

Do not forget that every one of those cars of the 80 per cent recovered cost you something if you pay insurance premiums, just as did the other 20 per cent more successfully stolen; further, that the $50,000,000 dead loss covers stolen property only and, as already pointed out, it does not begin to represent the attendant actual loss to owners through being deprived of their cars.

From a wholly negligible factor, when theft insurance actually was included with other insurance without an additional premium, theft-loss claims have risen rapidly to a position of 40.37 per cent of the total claim-business of the Underwriters Conference, or to $20,865,000 annually as their share of theft losses alone. This figure is net, after deductions for recovery, and it represents an average insurable value per car of about $850. It is estimated that only 30 per cent of the 20,000,000 cars in use last year were insured against theft; had all been insured, the pro rata to theft claims would have been almost $70,000,000.

The Underwriters can continue to raise rates, but it is not good business. The losses they have been complaining of are not on cars with a good theft-experience and low insurance-rates, but are just the reverse. Their losses occur on the cars having poor experience-rating and consequently high insurance-rates. Whether, for the immediate future, the Underwriters grant a 7½-per cent preferential rate on cars carrying Group-1*A* locks as standard equipment and 15 per cent on Group 1 as standard equipment, along with the abolishment of the 20-per cent allowance on Group-2 equipment, as has been freely predicted by some, or whether they do away with all preferential ratings and base premiums directly on experience, in the long run it seems but logical that theft insurance, like fire, accident and practically every other form of insurance, will be based on experience. With equal lock-equipment, the theft-experience with different makes of car will continue to vary and, even with the same car, will vary with difference in locality and with the seasons. Epidemics of thefts in certain localities will continue to break out from time to time.

If every builder is made to stand on his own feet and accept the insurance rate that experience with his car dictates, theft-retarding devices will come into use just in proportion to the sales resistance encountered, through high insurance-rates or sales advantage that the builder hopes to gain by their introduction. The Underwriters calculated wrongly before in appraising human nature, although they were right about locks the first time; now, they want another guess and the automobile builder has just so much justification for thinking that they may be wrong again. This time, it might be about locks; who knows? The car builder has never given the owner anything except with the idea of gaining a sales advantage or meeting competition. Wind shields, speedometers, tire carriers, bumpers, and the like were accessories; now, they are standard equipment, because some builder put them on one by one to gain a sales advantage. The public liked them and all companies had to follow. Left to take a natural course, all theft retardants, including coincidental locks, will come along the same way. It will take longer than if artificial stimulants are applied by the Underwriters, but the child will be all the stronger because of normal growth.

The Application of Group Bonus to Non-Productive Labor

By Joseph Lannen[1]

Annual Meeting Paper

ABSTRACT

In bringing about cost reduction in the automotive industry all branches of the industry have had a part. On the manufacturing side, one of the principal aids has been the application of wage incentives in the form of piecework, bonus and group-bonus systems of wage payment to direct labor, which was natural and logical because of the repetitive character of this work. As a result, it is difficult today to effect further great savings in the machining and assembling divisions. Other phases of manufacturing, however, among which is the so-called overhead or indirect labor, have not received the same consideration.

A description is given of the efforts to introduce wage-incentive systems into the tool-room, maintenance and machine-repair departments of the Paige-Detroit Motor Car Co., the results of which, in the opinion of the author, justify recording. Having been successful for several years in estimating within 10 per cent the costs of tools purchased from outside sources, the same method was applied to checking-up the company's own tool-room; and when this had been done the estimates were used as a basis for the development of a wage incentive for the tool-room. After having been in effect for 20 months, the average bonus earned was found to be 6 per cent of the wages paid. The maximum received in any single pay-period was 27 per cent. The bonus was not earned during 8 pay-periods.

Wage incentive was next applied to the maintenance division. As the work of this department is of two general types, construction and maintenance, the system was made successful eventually by first estimating the construction work and gradually taking in work of a maintenance nature. The machine repairmen were placed in a separate group and their work was estimated by the foreman. During the 4 months in which it has been in operation, the 74 men in the maintenance division have earned an average bonus of 10 per cent of their wages, the maximum bonus being 14 per cent, the minimum, 7. The machine-repair-department bonus has averaged 12 per cent, with the maximum of 20 and the minimum of 9 per cent.

The advantages derived from the form of wage payment adopted are said to be that it (*a*) provides the foreman with a means of checking the efficiency of the men, (*b*) provides the management with a means of checking the efficiency of the foreman and (*c*) enables the supervisor to show the management how and for what its money will be spent. The management, in turn, feels that it has control of what to it in the past was more or less of a mystery department.

Cost reduction is a problem in which everyone connected with the automotive industry is vitally interested and its continued downward trend is a credit to all who have aided in its accomplishment. No one division of the industry has been solely instrumental in this, for we all are familiar with the efforts of the engineer, the chemist and the metallurgist in the fields both of research and of development and the efforts of the administrative and manufacturing division of the industry toward lowering costs.

One of the principal aids toward cost reduction in manufacturing has been the application of wage incentives in the form of piecework, bonus and group-bonus systems of wage payment. The natural and logical beginning of these systems of wage payment was their application by the manufacturing division to what is termed direct labor, the reason being that this work is repetitive and comparatively easy to measure. This has made it a simple matter to determine the amount of money that could be invested with profit in labor-saving equipment and has established a scale of efficiency expected of those employed in this class of work. The result is that it is difficult today to effect great savings, especially in the machining and assembling divisions.

Although this field has been pretty thoroughly combed over, many other phases of manufacturing have not received the same consideration. Among these is the so-called overhead or indirect labor. Without going into a detailed description of what this consists of, I will endeavor to explain what has been done by the Paige-Detroit Motor Car Co. to measure and apply wage incentives to the tool-room, maintenance and machine-repair departments.

Description of System Adopted

The form of wage incentive decided upon and with slight variations applied to these three departments is as follows. An order is issued for each job. The work is then estimated, a copy of the estimate and order number is forwarded to the time department and the order is turned over to the department in which the work is done. The workmen's time is kept for each job and, at the end of the pay-period, the actual and estimated times for all jobs completed in this period are totaled. If the actual time is less than the estimated time, this difference is prorated among the group, being based on their earnings during the pay-period. If the time taken to do the work is greater than the estimated time, the men are paid the day rate. If a job is canceled, the original estimate is canceled, and an estimate of the actual number of hours that have been applied to the job is substituted. At the end of each pay-period, an estimate is submitted of the actual number of hours worked by each foreman who participates in the bonus. An estimate covering the actual number of extra hours allowed for overtime is forwarded to the time department at the end of the pay-period.

This type of incentive was first applied to the tool-room. It is not practicable to make time-studies of this type of work as is possible in production work and, at first thought, timing it would seem to be an impossibility, but this was worked out by a gradual development that I will outline.

Checking Own With Outside Costs

We had been estimating the cost of tools for several years and found it possible to secure tool estimators who

[1] Paige-Detroit Motor Car Co., Detroit.

could check-up with the outside tool-shop costs well within 10 per cent. In fact, any tool-shop that makes tools on contract must of necessity have someone capable of making estimates and, although it would be next to impossible to establish standards for this class of work, a man can acquire enough experience to estimate tools with a very close degree of accuracy.

As I have already stated, we had been estimating the cost of tools purchased from outside sources for a number of years. This practice was begun when we found that some companies charged considerably more than others for the work let out on a time-and-material basis, and that the tendency toward laxity on the part of nearly all tool-shops that received our work was general. We found that, by checking-up and calling their attention to the fact, we were able to secure the tools at an appreciable saving.

After having been successful in checking-up on outside tool sources, that we should apply the same method to checking-up our own tool-room was only natural. When this had been done, the idea of using the estimate as a basis for the development of a wage incentive for the tool-room had its inception and was carried out in the following manner.

Method of Estimating

The estimator's desk was moved into the tool-room and every job coming into the tool-room was estimated. We anticipated difficulty in estimating repair work but the problem was solved by estimating the cost of dismantling the jig or fixture to be repaired and, after the extent of the repairs required had been determined, estimating the amount of work necessary to put it into good condition. To keep an accurate record of the time applied to each job, it was necessary to install a clerk to keep time and to issue job tickets. This clerk also keeps a record of the time applied to each job.

One month after the estimator moved into the tool-room, the bonus system previously described was put into effect. This was in May, 1924, and it has been in effect during the subsequent 20 months. The average bonus earned during this period has been 6 per cent of the wages paid. The maximum received in any one pay-period was 27 per cent. Bonus was not earned during 8 pay-periods.

Besides being able to reduce the cost of tools, the following results were attained. We are able to predetermine the cost of building tools. The estimate enables the tool-room foreman to schedule the work and to give accurate promises as to when a job will be completed. It also shows the maximum number of toolmakers that can be employed without installing additional equipment, for lost time due to men waiting for machines affects the bonus and the men lose no time in calling this to the attention of the foreman. It promotes cooperation among the toolmakers.

To illustrate: an alteration to a conveyor made it necessary to mill, drill and tap 150 hooks. While one hook was being milled, the operator drilled one, and a lathe-hand, who was roughing a large piece of stock on another job, used his spare time between cuts to tap the hooks for the man who was milling and drilling them. This may astound those who know the genus toolmaker but, nevertheless, it happened.

The Group Principle

The group principle has the same effect on work in the tool-room that it has on production work: the men check-up on one another and complain if slow men are losing time on the jobs. This serves to increase the wages paid in the department. It is customary for automotive shops to pay a lower wage than that of the tool-shop, where work is not so steady; but this does not work out as well as one would expect for the following reasons. The men constantly feel that, if they were working in a jobbing-shop, they would make more money; and the best men could do so, for the jobbing-shop tries to hold its good men. This causes the foreman in the automobile tool-room to feel that, if he demands the same output as that of the jobbing-shop, the men will go where they can get jobbing-shop wages.

After the tool-room bonus had been installed, a natural sifting-out of those who could not or would not make a bonus occurred and, when the employment department attempted to replace them at the established rate, it found this to be impossible and was forced to increase the rate until at present our rate plus the bonus is equal to the average jobbing-shop rate. Another advantage of this system is that the department tries to complete as many jobs as possible before the end of each pay-period, so that it can collect bonus on them.

Application to Maintenance Division

After this form of wage incentive had been in successful operation for several months, it was decided to attempt to introduce it into the maintenance division. This, obviously, was a more difficult problem than that presented in applying it to the tool-room and required different means of application.

The maintenance division is made up of the following crafts, namely: millwrights, carpenters, electricians, pipe-fitters, painters, machine repairmen, beltmen, and oilers, and the work is of two general types: construction and maintenance.

The department was divided, therefore, into the two general groups, construction and maintenance. All construction was estimated by the supervisor of maintenance, the form of the bonus previously described was applied to it and work of a maintenance nature was given a bonus based on the number of cars built. The gains and losses accruing from these two forms of incentive were then added together and the resulting gain, if any, was divided among all the employes of the maintenance division.

This was not a success, owing to the fluctuation in the number of cars built and the fact that the maintenance work did not vary in accordance with the car production. It was found, however, that the time consumed on construction jobs averaged up well with the estimated time allowed for these jobs. Using this fact as a basis for further development, we decided to discontinue the maintenance bonus based on car production, and to attempt by degrees to cover all work as far as possible by estimates.

Timekeeping methods, as described in the case of the tool-room, were already in use but required further development to handle the added volume of work and to give the immediate service required, if the project were to be successful.

Increasing the Number of Estimators

It is apparent that it would be impossible for one man to estimate the work because of its volume and because a considerable portion of it is emergency work; if it is to be estimated at all, an estimator must be available at all times. Two men accordingly were added to the staff. These men, although not skilled in any of the crafts comprising the maintenance division, have a knowledge of general shopwork and are capable of making the plans and sketches necessary to determine how a job should be done. They had no previous experience in

estimating this type of work but, in a remarkably short time, with the assistance of the supervisor of maintenance, were able to give estimates that would average up well when totaled for a pay-period.

As I have stated, all the construction work was being estimated. We then gradually took in work of a maintenance nature until at present all this work is covered, with the exception of two beltmen, two oilers, two electricians, two steam-fitters, and four yardmen who are continually repairing railroad tracks. It was found necessary to separate the machine repairmen from this group and to provide a separate bonus for that department. Their work is estimated by the foreman.

Permitting a foreman to make his own estimates, although a departure from the general principle employed in estimating this class of work, has some possible advantages that may overcome its obvious disadvantages. It forces the foreman to give his men an allotted time in which to do their work and places in his hands a means of rewarding the men for good performance.

During the 4 months that this bonus system has been in operation, the maintenance division, which consists of 74 men, has earned an average bonus of 10 per cent of the wages. The maximum bonus received during a pay-period was 14 per cent and the minimum, 7 per cent. The machine-repair department has averaged 12 per cent, with the maximum of 20 per cent and the minimum of 9 per cent.

Conclusions

The successful development of this form of wage payment has many obvious advantages. It provides the foreman with a means of checking the efficiency of his men; it provides the management with a means of checking the efficiency of the foreman; and, last but not least, it enables the supervisor of these activities to show the management how and for what its money will be spent. The management, in turn, feels that it has control of what to it in the past was, more or less, a mystery department.

Measuring this type of work and applying incentive has to the best of my knowledge never before been attempted. Although it is comparatively new and untried, I feel that the methods employed in its installation and the results attained justify my passing them on to those who may wish to apply and develop them to a greater state of perfection.

THE DISCUSSION

W. W. NICHOLS[2]:—Mr. Lannen, how do you make up your estimates for repair jobs? Suppose that you have a breakdown job; is that estimated before or after the job has been completed?

JOSEPH LANNEN:—It is estimated as soon as possible.

MR. NICHOLS:—Suppose that you have a breakdown at night, for instance?

MR. LANNEN:—We do not have breakdown jobs at night that would involve the maintenance department. We do not usually run at night. We might have a boiler-house breakdown that would be taken care of by the powerhouse crew. If we ran a night force, we should need a night estimator.

MR. NICHOLS:—Have you worked out estimates on the basis of repairs for the length of bushings you want to bore out in that way? Have you gone into it as far as that?

MR. LANNEN:—No. We have an experienced man give the job the "once over" and decide how long it should take him to do it; and with his experience his figure is fairly close to the cost.

MR. NICHOLS:—Do you not find that this is of great benefit to you in going to the management?

MR. LANNEN:—Absolutely.

MR. NICHOLS:—When the tendency is to cut down the force, the maintenance gang suffers first, and the fact that this is so enables you to show the management exactly how many jobs are ahead of the maintenance gang.

MR. LANNEN:—I have been through that experience several times. The maintenance department is the first that the management reduces when it begins to cut down the force. Unless you have good statistics you are at a loss to explain why you need the number of men you have on the pay roll. But the way it works out is that a request is received to do a certain job. It is on a standard form known as the request-for-work order which is used throughout the plant whenever a request is made for the issuing of an order. All orders for construction expense or tools or manufacturing are issued from central points on receipt of a properly signed request. Before the order is issued, the work is estimated, and the order for the work is signed by the factory manager. Then, when the aforesaid factory manager tells how many men we should have, we produce the order with the estimated time and tell him how many jobs we have and how much time they will take. Then we ask him which of the orders he wishes to have canceled.

R. R. POTTER[3]:—The percentage of bonus earnings that you mention seems to be considerably lower than that usually earned on production work. What is the explanation for that?

MR. LANNEN:—You usually will find a very low day-rate on production work. The production man usually expects to get a good share of his wages from the bonus.

MR. POTTER:—Do you use a different scale of bonus reward on maintenance work?

MR. LANNEN:—We hire maintenance men as nearly as possible at the standard rates paid throughout the city. In fact, because the system is so new, it is almost impossible to hire men at a lower rate. Men engaged in maintenance are not particularly interested in the bonus at first. They get the bonus in addition to the standard rates. Bonus has the effect of raising the rate because men of the caliber required to work fast enough to obtain a bonus cannot be hired. When a slow man is hired, that fact comes to everybody's attention and the maintenance foreman must get that man out immediately or begin to lose on the bonus. Perhaps, out of 5 or 10 men, none will make good. Then the foreman says that it is the duty of the employment department to furnish the type of man that is needed. They may have to pay more for them, which automatically raises the rate. In other words, the bonus system demonstrates that it is profitable to hire good men.

MR. POTTER:—Do you have a different schedule of bonus payment, for obtaining an estimate on maintenance work, from that for a production job?

MR. LANNEN:—The bonus is of entirely different types. On production work, we establish a price per job. If we have a group of machines producing a part, we pay a certain price at the end of the line for the number of parts produced. That amount, which is the group-piece rate, is then divided among the operators.

A MEMBER:—With the percentage bonus, do the men having a higher rate get more than those having a lower rate?

MR. LANNEN:—The higher-rate men get more in proportion than those on a lower rate.

[2] M.S.A.E.—Assistant general manager and mechanical engineer, D. P. Brown & Co., Detroit.

[3] M.S.A.E.—Assistant to the president, Shakespeare Co., Kalamazoo, Mich.

MR. NICHOLS:—Is it your intention to break up the different jobs into units and use them as a basis for calculating a bonus later on?

MR. LANNEN:—We have not broken up the jobs into units. You mean electrical work and carpenter work, do you not?

MR. NICHOLS:—Yes.

MR. LANNEN:—Up to the present, the system has operated so smoothly that we have not felt the need of doing so. To get a close check, it might be advisable to do so. I have attempted it but considerable clerical work is required. The different crafts frequently interlock. When that happens, it would mean several estimates for a job instead of one.

W. W. NORTON[4]:—Has group bonus any distinct advantage over individual bonus? Tool-rooms generally have one man take a job almost all the way through.

MR. LANNEN:—Our tool-room works somewhat differently. With the quality of toolmaker gradually becoming poorer, we hire men as shaper hands, benchmen and so on. In that way, one man does not carry a job through. The principal advantage of the group method is that it eliminates considerable bookkeeping. If one man carried a job through, the time on each job could be ascertained easily. But, splitting up the tools and jigs and having several men work on the different details requires bookkeeping to keep the time of each operation and to separate the times later.

E. W. PUGHE[5]:—Does the estimator participate in the bonus?

MR. LANNEN:—No.

C. L. WILLIAMS[6]:—How do your costs run? With a bonus, is the cost of a given piece of work less than without the bonus?

MR. LANNEN:—Toolwork can be checked up in this way. Within a few months, a dozen jobs might be sent out, and the bids obtained from outside job shops are compared with our costs. We seem to average pretty well. We bid high and low just like an outside tool-shop, but our average seems to be about the same as the outside bids.

In maintenance work, there is no comparison. We know that we do not find the men loafing. When a man is out of work, he pesters the foreman until he gets something to do. When men are not producing, the men as well as the foreman and the management want to know why.

The fact that an estimate is made and that time is kept on jobs gives good control of the work that is in progress. We know at any time how many men and what men are employed on any job and what jobs are being carried through. If the management wishes to know the status of a job and it had been estimated as requiring 100 hr. of which 50 hr. had elapsed with three men engaged on it, conclusions could easily be drawn as to when it should be finished.

MR. WILLIAMS:—Can your maintenance-cost figures be compared at so much per job?

MR. LANNEN:—No; we have never attempted to do so. That is one feature of this system which is somewhat unsatisfactory, for comparison in figures cannot be made to show wherein the efficiency has been improved. But its method of operation is ample proof to me that it does help. If, for no other reason, the men have a certain time in which to complete a job, they know what that time is and try to beat it. The fact that they make a bonus is proof that they do beat it. They fool the estimator sometimes, just as in production they fool the time-study man; but, on the whole, the estimator is not fooled greatly for the reason that, if a man in the shop or a foreman is shown a job and is asked how long it will take, he will invariably make a lower estimate than the estimator; and 90 per cent of the time he will not be able to do the work as quickly as he thinks he can do it. It has been demonstrated to me that the estimate of the man on the job is low.

Sometimes a job goes through the tool-room on which the men lose out. The men say, "You didn't give us enough time." They will convince the tool-room foreman, who will go to the estimator to tell him about it. The estimator and the foreman then go over the job together. The method we use is to estimate each operation on each detail of the tool. The tool-room foreman and the estimator go over it detail by detail. The estimator gets the foreman to make the estimate and, when it is totaled, it is usually lower than that of the estimator. That, of course, settles the argument.

This method is more or less of an experiment. Our experience with it so far has led me to believe the experiment is worthwhile. The foreman on the job is very well satisfied with it because it shows the management what he is doing.

This method makes supervision much easier in some ways, especially during a period when work is beginning to be scarce and small jobs are being cleaned up. If the foreman is "on the job" to pass out the small jobs and keep the men busy, the efficiency will be maintained; but if he is not, it will show up on the bonus in a very short time.

MR. POTTER:—You said that the average bonus earned in the tool-room is 6 per cent. What percentage of the estimated time saved does that represent?

MR. LANNEN:—Our estimated time is 6 per cent over the day-rate earnings. The men did the work and saved 6 per cent of the total estimate.

MR. POTTER:—Are they given the full amount saved?

MR. LANNEN:—We began by giving them one-half the time saved, but the estimates seemed to be so close to the actual time that we decided it was best to give them all, to make it worthwhile.

MR. NORTON:—Did the toolmakers take hold of the bonus proposition with the same interest as the machine operators?

MR. LANNEN:—It seemed to grow on them. They did not pay much attention to it until they got a little money out of it. At the beginning, we endeavored to see to it that they did get some money out of it.

MR. NORTON:—You must introduce this method gradually with the machine operators, too, do you not?

MR. LANNEN:—Yes. In the maintenance division, as I stated in the paper, we had two types of bonus. When we discontinued the car bonus, which usually ate up all the bonus that was made, we had left only a small part of the maintenance division operating on the bonus based on estimates. We took construction work at first and kept a few men working on the bonus system. They began to collect a bonus, so the men who were not under the bonus system were in a receptive mood when we decided to put them on. Of course, that simplified things somewhat. No reduction was made in the day rate. That is the reason it is simple to install the system and it is much appreciated by the men. They like "free" money. I do not think they would appreciate it nearly so much if they were to get it by increasing their rates.

[4] M.S.A.E.—Vice-president and production manager, Autocar Co., Ardmore, Pa.

[5] Engineer, Chevrolet Motor Co., Detroit.

[6] M.S.A.E.—Efficiency engineer, Jaxon Steel Products division, General Motors Corporation, Jackson, Mich.

MR. NICHOLS:—You would not get the jobs out in the proportional time.

MR. LANNEN:—After a tool has been made, it is inspected and checked with the drawing. After the tools have been inspected, they are put on the job by a try-out man. He might find that a tool needed revamping somewhat. We find that this occurs more frequently in the tool-room than in maintenance work.

MR. NORTON:—Do you know of any cases in the tool-room in which feeling against some slower man was manifested?

MR. LANNEN:—Yes; plenty of them.

MR. NORTON:—What happens?

MR. LANNEN:—The foreman investigates them.

MR. WILLIAMS:—Did you find any trouble in "selling" the bonus idea to toolmakers?

MR. LANNEN:—No. I have often heard that difficulty has been experienced in installing bonus systems and I was worried when we first instituted this system, but personally I have never experienced great difficulty in this direction. It is a proposition that can be explained to the men in this way:

> You are earning a certain amount of money and will get that anyhow; but if you work faster and beat the estimates, you will get extra money. It is there if you want to get it.

After the men have begun to make the money, we demand that they make the bonus. It calls for attention on the part of the foreman. The foreman of the tool-room keeps track of the time and sees to it that the work does not lag. He finds out where the trouble is and tries to get the work into the proper time.

MR. WILLIAMS:—Then you have no penalty on the slow man as compared to the fast man?

MR. LANNEN:—No. The only thing that works against the slow man is the fast man.

MR. WILLIAMS:—Does that not cause trouble between the men?

MR. LANNEN:—It does as long as the slow man is there.

MR. WILLIAMS:—Are you able to get all fast men?

MR. LANNEN:—We have men that can beat the estimate.

MR. WILLIAMS:—Is it necessary to carry a steady force?

MR. LANNEN:—No, but it is desirable.

MR. WILLIAMS:—Your tool-room is for the maintenance of tools built outside?

MR. LANNEN:—That is the reason we have it, but we make probably 50 per cent of our tools. We employ about 40 men.

A MEMBER:—Does the bonus system reduce the cost of overhead in the department? How is the company benefited?

MR. LANNEN:—We feel that the company derives a benefit from the fact that the bonus system reduces the direct labor cost of building tools because the men work harder to turn them out. The overhead is not reduced. We have not only an estimator but also a clerk, who might be unnecessary if the bonus system were not in effect.

A MEMBER:—As the entire tool-room is expense in dollars and cents, I have wondered whether the bonus system reduced the total annual overhead expense.

MR. LANNEN:—We have no means of making comparison; one year is entirely different from the next, so that we cannot check up. Forty men is the maximum number that we can have in the tool-room now. Before the bonus was installed, we employed 67 men. After the bonus had been installed, we found that 40 men was the greatest number that could work efficiently with the equipment in our tool-room.

A MEMBER:—Then it reduces the amount of money annually by speeding-up the work?

MR. LANNEN:—This is difficult to prove. I feel sure that it does, but if it does nothing else, it measures the work. The management knows what is being done with its money. It is very comfortable to be able to say that the estimated cost of tools will be a certain amount and then find out that they really cost the estimated amount.

N. G. SHIDLE[7]:—Are there any men in your plant who are not in the group-bonus system; if so, do you think they would like to be, or is there feeling one way or the other?

MR. LANNEN:—There are still men who are not on group bonus, for instance, the tool inspectors. There does not seem to be very much dissatisfaction in that regard. I have looked for more than there is and have imagined that, when one department began to make a bonus, the other departments would think they should get one too; but it has not caused any apparent dissatisfaction so far. We have a few men in the maintenance division, for instance, a carpenter, who fixes the office furniture and does other work of that kind. We omit those men. The men in the powerhouse, too, are not on a bonus system.

MR. SHIDLE:—How about the sweepers and cleaners?

MR. LANNEN:—The sweepers are on a bonus, but it is a muddled-up affair and is being straightened out. We intend to put the sweepers on a floor-space basis, if it seems practicable to do so.

T. H. METZLER[8]:—I have a case and wonder whether you have had any experience along the same line. We had a young man as estimator, who was somewhat inexperienced. He was not well trained and, after he had become acquainted with the men, he became chummy with them. For that reason or others, the estimates became larger and the bonus climbed higher and higher. When this estimator was replaced with another one, the workmen did not like it, and it made a little bad feeling. Would that not be liable to happen frequently?

MR. LANNEN:—It is essential to have a trustworthy man, who is an experienced estimator, at the beginning.

MR. NORTON:—As I understand it, your method of payment is distributed over the entire tool-room force?

MR. LANNEN:—With the exception of the tool-room foreman, who is on a salary.

MR. NORTON:—Then every job in the tool-room is a bonus job?

MR. LANNEN:—Yes. The tool-room bonus is very easy to handle from the standpoint of getting all the estimates. We sometimes have a job that requires the toolmaker to go out into the shop and set-up a new machine. In that case we have time to estimate the job. Occasionally we leave a job that is impossible to estimate and, after it has been finished, make an estimate based on the actual number of hours taken. This method is simply a makeshift to keep the system in operation; but such jobs are so few that they are practically negligible.

MR. NORTON:—What effect did the bonus plan have on the labor turnover?

MR. LANNEN:—In the tool-room, it increased it, but a certain steady element was built up there, which, as time went on, had the effect of reducing the labor turnover. On the whole, I should say that the turnover was reduced.

[7] A.S.A.E.—Editor, *Automotive Industries*, Philadelphia.
[8] Ohio State University, Columbus, Ohio.

D. C. LARMOUTH[9]:—Did it increase the steady labor?

MR. LANNEN:—Yes. When a man feels that he can "play on the team," he naturally feels more interested in his job and likes to stay there.

MR. LARMOUTH:—I do not remember that you stated just how you pay the men. For instance, if you estimated 100 hr. for a certain job and the job required only 90 hr., what would be the distribution?

MR. LANNEN:—Ten hours is saved. The men get the 10 hr. and it would go into the pot for bonus.

C. M. SMILLIE, JR.[10]:—You mentioned the fact that a tool-room man may drop back 2 hr. through idleness, or lose the time on account of the carelessness of the foreman. How do you take care of that?

MR. LANNEN:—It is the foreman's duty to give him a job.

[9] Assistant to the metallographist, General Motors Corporation Research Laboratories, Detroit.

[10] Jun. S.A.E.—Mechanical engineer, Ternstedt Mfg. Co., Detroit.

MR. NORTON:—We tried the individual bonus plan and it was only partly successful.

MR. LANNEN:—What seemed to be the principal difficulty?

MR. NORTON:—Lack of interest on the part of the toolmakers. They did not take hold of it in the same way as the others in the factory. It worked with perhaps 10 per cent of the men.

MR. LANNEN:—Supervision has considerable to do with the success of the system. In the maintenance division, we have a large number of small groups, 8 or 10 carpenters, 15 millwrights and so on, each group having a supervising foreman. The men work on an hourly rate. If they work 100 hr. during the pay-period, an actual estimate for this number of hours is turned in, and the men participate in the bonus, which is reduced slightly. They participate only in the amount of bonus that is earned. All general foremen in charge of maintenance are on salary and are not included in the bonus system.

WHAT IS MEANT BY TRAFFIC CONGESTION?

THE first requisite for an adequate analysis of the problem of traffic congestion appears to be a careful definition of "congestion." The nearest approach to a formal definition that I have been able to find in the literature is the following:

> The meaning of the term "congestion" as applied to traffic conditions is that degree of overcrowding of vehicles in streets that obstructs freedom of circulation, with attendant consequences of economic waste and inconvenience.

But maximum freedom of circulation, convenience and economy for an individual vehicle is to be obtained only if no other vehicles are on the road. This is defining congestion by calling it overcrowding, which is not very helpful. The term is commonly used in two different senses, first, to indicate such a volume of traffic on the roads as to reduce the speed at which traffic moves below its potential maximum and which I will call "retardation of traffic," and, second, to indicate the presence on the roads of so great a number of vehicles as to reduce the "traffic capacity" of the roads, whose consequences I will term "suppression of traffic."

An increase in the number of vehicles on the road always tends to retard the rate of movement of the traffic. If the increase in the number of vehicles goes beyond a certain point it not only retards traffic but it reduces the volume of traffic which can be passed through the street per hour. Where the only speed restriction is that which is the automatic result of the number of vehicles on the road, reduction of speed retards traffic until the minimum speed of about 14 m.p.h. is reached, but increases traffic capacity; further reduction of speed not only retards but also suppresses traffic by reducing traffic capacity.

Estimates of the costs of congestion should take into account the economic loss due to suppression of traffic, which, for all we know, may be more important than retardation of traffic. The development of a satisfactory technique for estimating the costs of traffic congestion will not come until congestion is analyzed and dealt with in quantitative rather than qualitative terms.

For most, and probably for all, large American cities a program of providing in the congested areas ample facilities for all the traffic, whatever its type, which would offer itself if the facilities were there, would involve so staggering a cost that such a program would clearly be impracticable. To tolerate the persistence of a degree of traffic congestion so great as to reduce substantially the traffic capacity of the streets is clearly uneconomical also. The long-run program of dealing with the traffic problem must necessarily provide both for extension of facilities and for restriction of traffic. The general sentiment in support of the free and unrestricted use of the public streets is powerful, and headway against it can be made only very slowly. Nevertheless, traffic restriction is inevitable. If it is not applied by traffic officials in accordance with a carefully designed plan, it will come about automatically and in greater degree through the suppression of traffic resulting from acute congestion.

On purely economic grounds traffic restriction is always clearly preferable to the suppression and acute retardation of traffic resulting from extreme traffic congestion. Up to a certain point, which differs with circumstances and can be determined only approximately and by careful and expert survey of the situation, traffic restriction is more economical than the extension at great cost of existing traffic facilities. Traffic restriction would suppress traffic, but properly applied it would differ from the suppression of traffic resulting from acute congestion because it would not be accompanied by an impairment of the traffic capacity of the existing highway facilities, and it would select the traffic to be suppressed in accordance with the economic importance of different types of traffic instead of arbitrarily.

Unless the volume of traffic in the absence of restrictions is so great as to retard the speed of traffic movement substantially below the rate at which traffic capacity would be at its maximum for that highway no restrictions should be imposed. In congested areas speed above the rate that brings maximum traffic capacity is to be regarded as an expensive luxury and to be given little extra consideration; inability to maintain that optimum speed is, on the other hand, an expensive nuisance and should be dealt with accordingly.

The most common test applied to different types of passenger carriers using surface ways is square feet of space occupied per seat. This is inadequate in a number of respects. Among the additional factors that should always be given consideration are the possibilities of reasonable overload at traffic peaks, the speeds per mile in conjunction with the corresponding minima of side-clearance and safe braking-distance and the interference with other types of traffic.—From a report by Jacob Viner, of the University of Chicago, to Highway Research Board of National Research Council.

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Volatility Tests for Automobile Fuels

By T. S. Sligh, Jr.[1]

Semi-Annual Meeting Paper *Illustrated with* Charts

ABSTRACT

ELEMENTARY theories regarding the evaporation characteristics of pure substances and mixed liquids are discussed briefly and the difficulties likely to be encountered in attempts to calculate the volatilities of motor fuels from data relating to pure substances or in the extrapolation of volatility data corresponding to the atmospheric boiling-range of the fuel to the range of temperatures encountered in utilization of the fuel are pointed out. A brief review of previous methods of arriving at fuel volatility is also presented.

Volatility, as applied to motor fuels, is defined as being measured by the percentage of a given quantity of the fuel which can be evaporated under equilibrium conditions into a specified volume. The weight of air under known pressures is taken as a convenient measure of the volume.

The new method described is an equilibrium distillation of the fuel in the presence of a known weight of air. The fuel is supplied at a predetermined rate by displacement from a reservoir by the fall of a clock-controlled cylinder, and flows into a long metal helix immersed in a bath at the temperature of the test. Air is also delivered to this helix at a predetermined rate, as measured by a small-orifice meter. Evaporation takes place to equilibrium, and the uncondensed fuel is drained from the lower end of the helix and measured. By such means the distillation curve for the fuel in any desired air-fuel mixture can be determined accurately.

Data are presented for five fuels of varied characteristics which had also been used in engine tests of starting volatility. Such volatility data will be useful in connection with studies of engine performance, carburetion, the blending of fuels, and the production of fuels for specified performance.

THIS paper represents a report of the work done to date on the measurement of motor-fuel volatility, which has been carried on in connection with the Cooperative Fuel Research program[2].

The term volatility is commonly used to denote the property of a substance which permits it to be readily or easily vaporized. It is in this sense that the term is used as applied to motor fuels. However, if the term is to be used in a quantitative sense, it is necessary to define volatility in terms of definite measurable quantities and, for the purpose of this presentation at least, volatility at a definite temperature as applied to fuels will be regarded as measured by the percentage of some definite quantity of the fuel which can be vaporized into a given volume at the specified temperature.

It would be logical to define volatility for complete vaporization at the specified temperature as the weight of the substance which can be evaporated completely into unit volume at that temperature. This is the definition of the density of a saturated vapor; but, in dealing with fuels, since the principal interest lies in the quantity of fuel that can be evaporated at a given temperature into the space occupied by a given weight of air, it seems convenient to specify the space into which the fuel is to be vaporized in terms of the volume of a given weight of air at the specified temperature and pressure.

This idea will be developed further, but it should be remembered that vaporization into a given *weight* of air at a specified temperature and pressure is equivalent, so far as the final quantity vaporized is concerned, to evaporation into the *empty space* which would be occupied by that weight of air. To emphasize this still further, presence of more or less air in a given space may affect the *rate* at which the space becomes saturated with the vapor of the substance, but not the *quantity* of the vaporized substance that will be required to saturate the space at a given temperature. For instance at 25 deg. cent. (77 deg. fahr.) only 23 grams of water vapor will evaporate into 1 cu. m. (1.308 cu. yd.) of space, and only this weight of water vapor will evaporate into that space whether it contains 1.56 grams of air at a pressure of 1 mm. (0.03937 in.) of mercury, or 11,850 grams at a pressure of 10 atmospheres.

To use "weight of air" as a convenient measure of volume, the temperature and also the pressure, usually taken as 1 standard atmosphere—760 mm. (29.92 in.) of mercury at 0 deg. cent. (32 deg. fahr.)—must be specified. The reason for the emphasis on this point will appear in the discussion of starting volatility. To form a definite picture of the mechanism of evaporation of a fuel, this process will be discussed in the light of the kinetic theory of heat, particularly as applied to gases.

According to the elementary theory a perfect gas and, with certain limitations, any vapor, can be pictured as being composed of a very large number of small perfectly elastic particles called molecules which move at random. The particles are small with respect to their average distance apart, and exert no appreciable attraction upon each other. When heat energy is imparted to a substance, it goes largely to increase the molecular kinetic energy through an increase in the average velocity of the molecules and also to increase the average spacing of the molecules. Heat imparted to a solid or to a fluid is also largely absorbed in this way. Heat is regarded as energy that is stored in the molecules of a body and temperature, absolute, as being proportional to the square of the average random velocity of the molecules of the gas. The general law of gases, $PVM = mRT$, can be derived from these concepts, in which P represents the pressure, V is the volume and M equals the molecular weight of a mass, m, of gas at an absolute temperature, T. The universal constant R has a value that is independent of the particular gas employed and depends upon the units in which the other quantities are expressed. This general law embraces the experimental laws of Boyle and Charles, that PV/T = a constant, and of Avogadro, that "equal volumes of all gases under the same conditions of pressure and temperature contain

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[1] M.S.A.E.—Physicist, Bureau of Standards, City of Washington.

[2] This Cooperative Fuel Research has been in progress at the Bureau of Standards since August, 1922, under the direction of a Steering Committee composed of representatives of the cooperating organizations, which are the American Petroleum Institute, the National Automobile Chamber of Commerce, the Bureau of Standards and the Society. For reports of previous work, see The Journal, February, 1923, p. 139; July, 1923, p. 3; March, 1924, p. 268; July, 1924, p. 69; October, 1924, p. 334; February, 1925, p. 237; July, 1925, p. 52; and February, 1926, p. 147. For reports of test methods developed in connection with this program, see The Journal, March, 1925, p. 355 and April, 1926, p. 393

the same number of molecules." Another equally general law is that of Dalton, which states that

> The total pressure exerted in a given volume by a mixture of gases which do not react chemically with each other is equal to the sum of the pressures which each gas would exert if it occupied the space alone at the same temperature.

When heat is applied to a liquid, some expansion takes place; but most of the energy goes to increase the velocity of the molecules and this increased velocity appears as an increased temperature. Some of the high-velocity molecules will strike the liquid surface from below and go out into the space above. If this space is enclosed so that the molecules cannot escape from the vessel, some of them will strike the liquid surface from above with sufficient velocity to re-enter the liquid. At any given temperature a state of equilibrium will be reached where the number of molecules entering and leaving the liquid per unit time are equal, and the space above the liquid is then said to be saturated. The pressure then exerted by the molecules in the vapor is a definite characteristic of the substance which is called the pressure of the saturated vapor or, simply, the vapor-pressure. This pressure is equal to the pressure which would be exerted at that temperature by an equal number of molecules of any other gas or vapor occupying the same volume. Vapor pressure, molecular weight and mass of substance in the vapor state per unit of volume are related so that, if two of these quantities are known, the third can be calculated.

When the temperature of a liquid-vapor system is raised, the concentration of the molecules in the space above the liquid tends to be increased and the rate at which evaporation takes place to reestablish vapor equilibrium at the higher temperature depends upon the vapor-pressure of the substance, its molecular weight and the concentration of the vapor above the liquid. When the temperature is such that the vapor-pressure slightly exceeds the total external pressure, vapor may be liberated throughout the body of the liquid as well as at the surface. This form of evaporation is known as boiling. Thus, in an ordinary distillation, when the pressure of the vapor slightly exceeds atmospheric pressure, vapor will flow from the distillation flask, reducing the vapor concentration in the flask and permitting further evaporation from the liquid.

Evaporation is opposed by the presence of molecules of the evaporating substance in the space above the liquid and can be promoted by removing these molecules. This can be accomplished by reducing the total pressure on the system below the vapor-pressure at the existing temperature, either by pumping the vapor away as with a vacuum pump or by sweeping the molecules away from the surface by a stream of inert gas; that is, a gas which does not, under the existing conditions, combine with or dissolve in the evaporating substance. Steam distillation as practised in refinery operations is an example of this.

If the contact between the evaporating liquid and the inert gas is sufficiently prolonged to permit the attainment of vapor equilibrium, the space occupied by the resultant stream of gas will be saturated with the vapor at the vapor-pressure of the substance corresponding to that temperature. The quantity of liquid which will be so evaporated can be calculated from the vapor-pressure of the liquid at the existing temperature, its molecular weight and the volume of gas used; or, since gas volume and weight are definitely related, the calculation can be made in terms of the weight of gas used. Thus it is evident that, if the vapor-pressure-temperature relations of a substance and its molecular weight be known, its behavior can be calculated readily for various conditions of evaporation.

The application of these principles to the evaporation of pure substances where the molecular composition of the first fraction evaporated is the same as that of the last is relatively simple. When, however, the evaporation of a solution of two or more substances is considered, the problem becomes more difficult for we then have to deal with two or more species of molecule. For solutions of normal liquids, that is, for liquids in which the molecules are neither associated into groups nor dissociated into ions, the resultant vapor-pressure and the composition of the vapor which is in equilibrium with a liquid of known composition can be calculated by Raoult's law, stated as follows:

> Above a solution of normal liquids the partial pressure exerted by any component is proportional to the product of the vapor-pressure of that component at the existing temperature and its molecular concentration in the solution.

The molecular concentration or "mol fraction" of a component in a given solution is the ratio of the number of molecules of the component in the solution to the total number of molecules in the solution. If weights W_A and W_B are taken of two components A and B having molecular weights M_A and M_B, the total number of molecules in the solution is proportional to M_o, where

$$M_o = (W_A/M_A) + (W_B/M_B) \tag{1}$$

and the mol fraction F_A of component A in the solution is

$$F_A = (W_A/M_A)/M_o \tag{2}$$

and similarly

$$F_B = (W_B/M_B)/M_o \tag{3}$$

If the vapor-pressures of the components A and B at the test temperature be represented by P_A and P_B respectively, the partial pressures p_A and p_B which the components in the solution will exert in the space above the liquid under saturation conditions will be

$$p_A = (P_A/M_o)\ (W_A/M_A) \tag{4}$$

and

$$p_B = (P_B/M_o)\ (W_B/M_B) \tag{5}$$

Equations (4) and (5) are mathematical statements of Raoult's law.

The total pressure $P_o = p_a + p_b$, according to Dalton's law, and the mol fractions V_A and V_B of the components in the vapor will be, respectively

$$V_A = p_A/P_o \tag{6}$$

and

$$V_B = p_B/P_o \tag{7}$$

The weight of each component in a given space occupied by the mixed vapor can be calculated from equations (6) and (7). Obviously, such calculations become rather involved when more than two components are present in the solution. The foregoing presents the simple theory of vapor-pressures of solutions of liquids which can be found in standard treatises on physical chemistry. It is seen that the composition of the vapor over a solution of liquids is dependent upon both the composition of the solution and upon the vapor-pressures of the components at the existing temperature. In general, the composition of the vapor is different from that of the solution. In the comparatively rare cases in which the liquid and the vapor have the same composition, which exceptions occur with associated liquid, we have constant boiling mixtures of which ethyl alcohol containing about 5 per cent of

water is an example. Except in such cases, the vapor is richer in the lower-boiling components than is the solution. Equations (1) to (7) indicate how the composition of the vapor which is in equilibrium with a solution or mixture of given composition at a given temperature depends upon both the concentrations of the components in the mixture and their relative vapor-pressures at the given temperature.

Vapor-Pressure Ratios

Fig. 1, which has been plotted from recognized data, shows the ratios of the vapor-pressures at various temperatures of several pairs of the petroleum hydrocarbons which occur in gasolines. It is seen that the ratio of the vapor-pressures of a more volatile to a less volatile liquid, such as shown by the curve for octane and decane for instance, increases with decreasing temperature from 2.30 at 160 deg. cent. (320 deg. fahr.) to 6.65 at 0 deg. cent. (32 deg. fahr.). This, in connection with equations (1) to (7), indicates that better separation is possible by simple evaporation at low than at high temperatures, and that the rate of change of vapor composition with temperature is greater at low than at high temperatures. A consideration of these relations emphasizes the decided effect of temperature of evaporation of a mixture of hydrocarbons such as gasoline upon the composition of the vapor at different stages of evaporation.

A mixture of liquids will show, when undergoing evaporation, a constantly changing composition and will give off a vapor of changing composition as evaporation proceeds. If it is desired to observe the boiling-point of a solution which will give off a vapor of a *particular fixed composition*, it is necessary to feed continuously into the evaporating solution a liquid having the composition of the vapor in such quantities as to just make up for the evaporation. When equilibrium has been attained, the composition and quantity of the vapor going off must be the same as the composition and the quantity of the liquid being fed into the system. The temperature is the equilibrium boiling-point of the feed liquid, under the existing pressure, and the solution from which evaporation takes place has the composition of the first small quantity of liquid which would be condensed at that temperature from a vapor having the composition of the feed liquid.

A conclusion from Raoult's law is that, since the composition of the vapor from a solution of known composition, or, conversely, the composition of the solution from which a vapor of specified composition will be evaporated, is a function of the relative vapor-pressures of the components of the solution and, since the ratios of the vapor-pressures of compounds are not the same at all temperatures, the composition of the solution which is in equilibrium with a vapor of fixed composition, for instance, the vapor of a completely vaporized fuel, at the boiling-point at atmospheric pressure will, in general, not be the same as the corresponding solution for evaporation at lower temperature. It has been shown by D. P. Barnard, 4th, and R. E. Wilson[3] for instance, that the dew-points of motor fuels derived from measurements on equilibrium solutions prepared at the atmospheric boiling-point are not the same as those resulting from direct observations on air-fuel mixtures.

It appears that measurements of relative volatility characteristics of unknown mixtures at high, atmospheric-boiling-point, temperatures can alone give no exact information as to the relative volatility characteristics of the mixtures at low temperatures, except insofar as the mixtures compared may happen to be similar as regards the quantity and the species of compounds.

The application of the foregoing principles to the calculation of volatilities of motor fuels is complicated by the presence of a very large number of compounds in the fuel, and by the fact that it is not feasible commercially to produce motor fuels on a definite composition basis. It does not seem practicable, therefore, to calculate volatility data for engine conditions on the basis of the characteristics of the constituents or on volatility data taken at relatively high temperatures, and the resort must be had to methods of direct measurement.

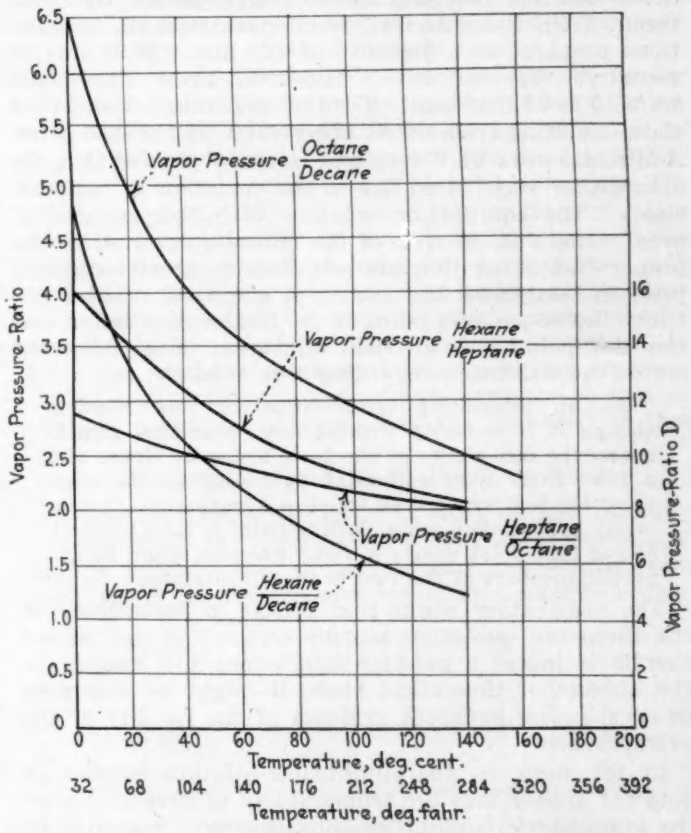

Fig. 1—Ratios of Vapor-Pressures at Various Temperatures Several Pairs of the Petroleum Hydrocarbons Which Occur in Gasoline Are Considered. The Ratio of the Vapor Pressures of a More Volatile to a Less Volatile Liquid Increases with Decreasing Temperature. In Connection with Equations (1) to (7), This Indicates That Better Separation Is Possible by Simple Evaporation at Low Than at High Temperatures, and That the Rate of Change of Vapor-Composition with Temperature Is Greater at Low Than at High Temperatures

Previous Work

With regard to the equilibrium-solution method, a method of measuring fuel volatility was proposed by Wilson and Barnard[4] which consisted of the preparation of an equilibrium solution at a vapor-pressure of 1 atmosphere by feeding the fuel continuously into a heated flask containing a fixed volume of solution at such a rate as to just replace the evaporation. This process was continued until from 7 to 10 times the volume of the solution in the flask had been distilled through and the temperature had ceased to rise, indicating that a state of equilibrium between the liquid and the vapor of the whole fuel had been reached. The vapor-pressures of this solution were measured over the desired range by a static method. These data, together with the average molecular weight of the fuel estimated from the Engler

[3] See *Industrial and Engineering Chemistry*, April, 1925, p. 428.

[4] See *Journal of Industrial and Engineering Chemistry*, October, 1921, p. 906; see also The Journal, March, 1923, p. 287.

distillation-curve, permitted the calculation of the dew-points of the fuel in various air-fuel mixtures. The expression "dew-point of the air-fuel mixture" denotes the temperature at which the vapor of the whole fuel will just begin to condense from the air-fuel mixture. Probably the term *saturation temperature* is better, since it carries the idea of a temperature at which the space occupied by the air-fuel mixture is just saturated with the vapor of the whole fuel.

The validity of the equilibrium-solution method rests on the question of the constancy of the composition of equilibrium solutions prepared at high and at low vapor-pressures. Measurements on a solution prepared at a pressure of 130 mm. (5.12 in.) of mercury, the lowest pressure at which the procedure seemed feasible, indicated that the resultant dew-points were not very different from those derived from measurements on solutions prepared at a pressure of 760 mm. (29.92 in.) of mercury, vapor-pressure. However, these dew-points were 15 to 20 deg. cent. (27 to 36 deg. fahr.) lower than those resulting from direct observation of the dew-point. Additional work by Wilson and Barnard[5] showed that the discrepancy was indeed due to the variation in composition of the equilibrium solution with temperature of preparation and, in view of the difficulty involved in the preparation of equilibrium solutions at greatly reduced pressure, suggested the use of an empirical relation between the 85-per cent point of the Engler distillation and the dew-points of air-fuel mixtures. The following statement was made regarding this relation:

> As an interesting confirmation of this relation, though it is probably without any theoretical significance, the dew-points of the fuels tested by Gruse and a few others were estimated by taking as the dew-point the temperature at which a hypothetical (petroleum) hydrocarbon whose boiling-point is the (Engler) 85-per cent point exerts a vapor-pressure equal to the partial pressure of the fuel in the air mixture.

The explanatory words that appear in parentheses in the foregoing quotation are my own. The fact stated therein is indeed a peculiar coincidence and, except for the absence of theoretical basis, it might be construed as constituting sufficient evidence of the validity of the extrapolation.

In the work on the equilibrium-solution method, it does not appear that the temperatures of preparation of the atmospheric equilibrium-solutions were regarded as especially significant. These temperatures were recorded in the earlier publications, but were not used in arriving at the final results. This temperature is, however, the end-point of the equilibrium distillation, at atmospheric vapor-pressure, being a distillation in which the fuel is vaporized in equilibrium with a vapor having a composition representative of all that portion of the fuel which has previously been distilled.

Direct Dew-Point Observations

As to the dynamic method, a more direct means of arriving at fuel volatility was employed by W. A. Gruse[6], who mixed air and fuel in definite proportions at a temperature well above the dry-point and observed the temperature at which condensation just began to take place on a cooled mirror in the air-fuel stream. Measurements were made of a number of fuels with what appears to be satisfactory precision. This dynamic method appears to be free from possible adsorption troubles, but it seems to have been rather tedious as the author stresses the importance of having two operators make alternate observations. This method apparently has not been used since, by the originator or by other experimenters.

Dew-Point by the Static Method

R. J. Kennedy[7] also made measurements of the dew-points of air-fuel mixtures by a static method which consisted in evaporating a known weight of fuel in a large flask of known volume and observing the temperature at which condensation just began to take place on a portion of the flask which was cooled slightly below the temperature of the surrounding bath. Molecular weights of the fuels were calculated from the pressure exerted by a known weight of fuel vapor in the flask at a definite temperature, and observed dew-points were extrapolated to even values of air-fuel ratios. These measurements are in substantial agreement with those of Gruse and of Stevenson and Stark, those of the latter being discussed later; however, there does seem to be the probability of complications in work with small quantities of fuels by static methods due to possible adsorption of fuel on the walls of the confining vessel or by a film of extraneous matter.

Static Phase-Change Method

Work has also been done on a static phase-change method by Stevenson and Stark[8]. The method consisted essentially in evaporating a known quantity of fuel in a known volume containing air, and observing the pressure on the system as the temperature was reduced by successive steps. Similar observations were taken with increasing temperatures, and the transition in the rate of change of pressure with temperature was evaluated from a plot of the pressure-temperature data. The temperature corresponding to this transition point was taken as the dew-point of the charge. The agreement between results with increasing and decreasing temperature was taken as an indication that the dew-point of the mixture was the same as the temperature of complete equilibrium vaporization.

The average molecular weight of the fuel was determined by the freezing-point depression-method using benzene, C_6H_6, as the solvent and this, together with the weight of fuel required to saturate a known volume with vapor at a known temperature—the dew-point as already described—permitted the calculation of the corresponding vapor-pressures of the completely vaporized fuel. Such data were taken over a vapor-pressure range of from about 10 to 800 mm. (0.3937 to 31.5000 in.) of mercury, and the vapor-pressure curve of the completely vaporized fuel was plotted. Direct dew-point observations were made to afford independent check-tests.

The end-point of the equilibrium distillation at atmospheric pressure, as determined by the phase-change method, was emphasized as a unique characteristic of the fuel and was called the Deppe end-point by Stevenson and Stark. A plot was presented showing the relation between the Deppe end-point and the saturation temperatures in various air-fuel mixtures. It was proposed that the saturation temperatures, or dew-point, of air-fuel mixtures for any fuel could be determined by measurement of the Deppe end-point of the fuel and reference to this plot. This relation seems analogous to the relation between the 85-per cent point of the Engler distillation and the saturation temperatures of air-fuel mixtures; moreover, a theoretical basis for the relation is not suggested and the number and variety of fuels

[5] See *Industrial and Engineering Chemistry*, April, 1925, p. 428.
[6] See *Industrial and Engineering Chemistry*, August, 1923, p. 796.
[7] See Bureau of Standards Scientific Paper No. 500.
[8] See *Industrial and Engineering Chemistry*, July, 1925, p. 678.

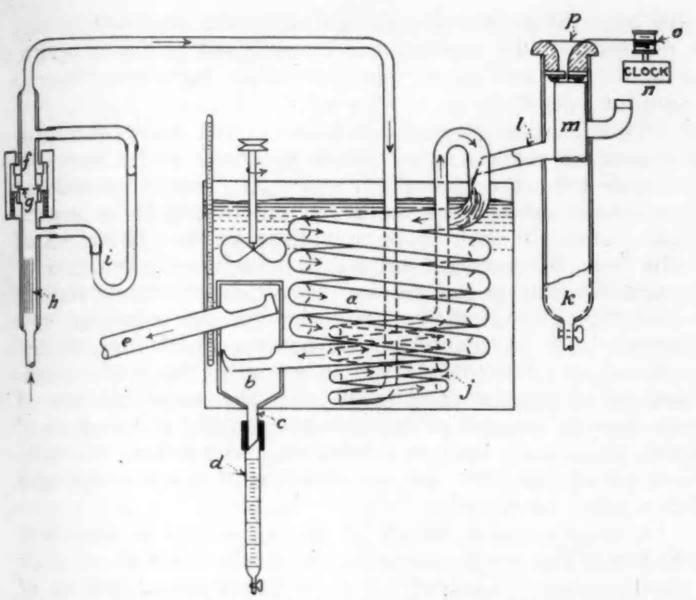

FIG. 2—APPARATUS FOR MEASUREMENT OF FUEL VOLATILITY UNDER CONDITIONS OF UTILIZATION IN THE ENGINE

The Evaporator Element *a* Is a Helix about 4 In. in Diameter, Formed of about 16 Ft. of 3/16-In. Metal-Tubing. The Lower End of the Helix Delivers into a Separating Chamber or Trap, *b*, from Which a Short 3/16-In. Tube Drains the Unevaporated Liquid to a Graduated Tube, *d*. The Air-Fuel Vapor Mixture Is Discharged to Waste at *e*

dealt with seems too small to justify a broad generalization.

In this work, an equilibrium distillation was also carried through and the difference between such a distillation and the Engler distillation was stressed particularly. Equilibrium distillation was contrasted with fractional distillation and the equilibrium end-point of complete vaporization was shown to be about 60 deg. cent. (140 deg. fahr.) below the Engler end-point. Curves were plotted that showed "mol percentages" and the percentages by weight distilled at various temperatures. This seems to have been the first presentation of such data relating to motor fuels. The methods used in this work were admirable but the manipulations required are such as to tend to discourage one possessed of only ordinary skill.

Miniature Pipe-Still Method

Recently, W. S. James[8] described a method which consists in feeding fuel into a miniature pipe-still maintained at a constant temperature at a rate sufficiently slow, 2 to 4 cc. per min., to permit attainment of equilibrium at the test temperature. The unevaporated fuel is drained to a graduate and measured, and the evaporated fuel is wasted. From the measurement of unevaporated liquid corresponding to a given quantity supplied, the percentage of the fuel which is evaporated under equilibrium conditions can be determined. Repetitions of this process at various temperatures give the equilibrium distillation curve of the fuel at atmospheric vapor-pressure. The results of such a distillation are said to differ from those of the Engler distillation in that the temperature range is reduced greatly and the percentage evaporated bears an approximately linear relationship to the temperature. The following statement is made regarding the test:

> If the laboratory continuous distillation of motor fuels is truly representative of the process of distillation in an engine, it should be possible to translate the temperatures of test into those of use if an estimate can be made of (*a*) the reduction of hydrocarbon-vapor pressure due to the presence of air and (*b*) the effect of pressure on the temperature of vaporization.

A method of making such an extrapolation is described which consists essentially in assuming that the average molecular weight of the fuel is the same as that of the hypothetical pure hydrocarbon having a normal boiling-point—760 mm. (29.92 in.) of mercury—equal to the point of 50-per cent evaporation of the fuel, and assuming further that the change of vapor-pressure of the 100-per cent-evaporated fuel with temperature is the same as that for a hypothetical pure petroleum hydrocarbon having a normal boiling-point equal to the temperature at which the fuel is 100 per cent vaporized in the test. The temperature at which the fuel will be completely evaporated into a given air-fuel mixture at any desired pressure can then be calculated from these vapor-pressure and molecular-weight data.

It is suggested also that starting volatility can be determined in a similar manner by considering some region in the lower part of the distillation range, such as 0 to 20 per cent evaporated. Charts are presented to facilitate the graphical evaluation of desired data from the distillation data. That this suggested method of extrapolation is regarded by its author as tentative only is indicated by the expressed hope that further work will be done to make the translation of boiling-points from atmospheric pressure to lower temperatures sufficiently accurate for practical purposes, and the statement, in discussion, that the question of translating the temperature of vaporization at atmospheric pressure to that at very much reduced pressure was not answered at that time.

Conclusions Applying to Previous Work

A consideration of the previous work on fuel volatility indicates that (*a*) direct observations of dew-points of air-fuel mixtures are at best tedious and a number of observations are necessary to establish a point definitely,

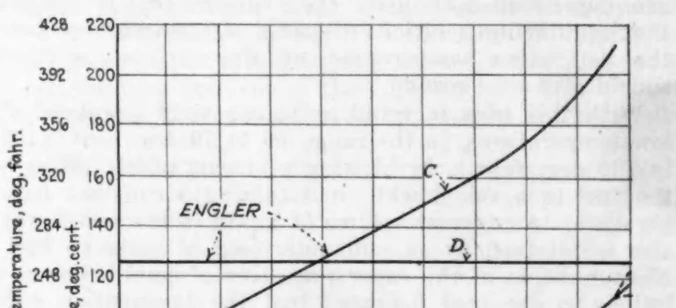

FIG. 3—AIR EQUILIBRIUM-DISTILLATION OF AN AVERAGE GASOLINE IN THE PRESENCE OF 15 TIMES ITS WEIGHT OF AIR

It Should Be Noted That the Curve from 30 or 40 to 95 or 100 Per Cent Is Practically a Straight Line, and That the Lower End Breaks Away Sharply

[8] See THE JOURNAL, May, 1926, p. 501.

(b) equilibrium-solution methods are applicable only when the solution can be prepared at or near the temperatures for which data are desired, (c) static methods involving the use of small quantities of fuel require great care if adsorption effects of the walls of the containing vessel or of impurities are to be avoided, and (d) while empirical relations connecting some point on the Engler distillation curve or on the equilibrium distillation curve at atmospheric vapor-pressure with the saturation temperature of the air-fuel mixture have been proposed, no rational method of extrapolation has been developed.

It does not seem probable that any definite relation can exist between any point on the Engler or on the atmospheric equilibrium-distillation curves and the saturation temperatures of air-fuel mixtures which is independent of (a) the composition of the fuel and (b) the relative proportions of the components. While it may be that at present the compositions of the majority of automotive fuels are sufficiently alike to permit the use of such empirical relations, it seems that such relations should be regarded purely as convenient approximations.

Equilibrium-Air Distillation

Considerable work has been done in the Bureau of Standards laboratory on various modifications of the equilibrium-solution methods at reduced vapor-pressures. Work under vacuum was so complicated by difficulties of manipulation, however, as to offer little promise. Observations of equilibrium end-point temperatures involving the use of steam at atmospheric pressure gave some information, but the method was inflexible in that it did not permit measurements at sufficiently low fuel-vapor pressures.

Since it appears that the composition of the solution which is in equilibrium with a vapor of given composition is dependent only upon the relative vapor-pressures of the components of the solutions and, since these ratios are dependent only upon the temperature, it seemed that equilibrium solutions prepared at *temperatures* near the saturation temperature of the air-fuel mixture should give true results.

With this idea in mind, solutions were prepared at low temperatures, in the range 50 to 70 deg. cent. (122 to 138 deg. fahr.), by blowing a stream of air through the fuel in a vessel while maintaining a constant temperature. A constant volume of liquid in the vessel was also maintained by an automatic feed of make-up fuel. Measurements of the vapor pressures of equilibrium solutions so prepared indicated that the composition was dependent upon the temperature of preparation and independent of the rate at which air was blown through the solution, and these measurements indicated a dew-point which seemed reasonable and were decidedly higher than those obtained by vapor-pressure measurements on the solution prepared at the atmospheric boiling-point. This work was not, however, carried beyond the stage which indicated accuracy but little promise of simplification to a suitable degree.

Air-Fuel Distillation Method

The method of attack which seems most promising consists essentially in supplying air and liquid fuel at measured rates to an evaporating coil, observing the temperature corresponding to equilibrium, separating and measuring the unevaporated liquid and, from data taken at the desired temperatures, plotting the distillation curve of the fuel in the presence of known amounts of air. Thus, the distillation curve for the fuel in any desired air-fuel mixture can be obtained at the temperatures and fuel-vapor concentrations corresponding to engine operation.

This general method has been in the foreground for a year or more as one which appeared to be very desirable from the theoretical viewpoint, since it permitted measurement of fuel volatility under conditions practically identical with those prevailing in the utilization of the fuel. However, it seemed to present very real practical difficulties in the precise control and measurement of fuel-flow and air-flow. The satisfactory solution now seems to lie in control and measurement of fuel by displacement of the fuel from a reservoir by a clock-controlled displacement-cylinder and the measurement of air-flow by a small orifice-meter. A brief description of this apparatus, then in course of construction, was presented at the 1926 Annual Meeting of the Society, and was later published[10].

A diagrammatic sketch of the apparatus is shown in Fig. 2. The evaporator element *a* is a helix about 4 in. in diameter formed of about 16 ft. of metal tubing of 7/16-in. outside-diameter. The lower end of the helix delivers into a separating chamber or trap, *b*, from which a short tube, *c*, about 3/16 in. in diameter, drains the unevaporated liquid to a graduated tube, *d*. The air-fuel vapor mixture is discharged to waste at *e*.

Air is supplied from a low-pressure system, 1.5 lb. per sq. in. is sufficient, and is measured by the orifice meter *f* which consists of a thin disc, *g*, through which is bored a small hole 5/32 in. in diameter and which has square edges. The tubes *h* serve to eliminate swirls in the air-stream ahead of the orifice. The pressure-drop across the orifice is measured on the water manometer *i*, which connects to the pressure taps. The air is brought to the temperature of the bath in the helix *j* before entering the evaporator helix *a*. Fuel is delivered from the reservoir *k* through the sloping tube *l* which fits closely into a tube soldered to the helix and is sealed with a short length of rubber tube or can be soldered, if desired.

The rate of fuel feed is determined by the rate of fall of the displacement plunger *m*, which is controlled by the clock mechanism *n*. This is a clock such as is used to drive the chart on recording devices and makes one revolution in 15 min. A drum, *o*, is mounted on the main shaft through a ratchet-clutch to permit rewinding the wire which runs on the drum. This wire passes through the cup *p* which carries a stuffing-box to prevent leakage of air and is connected to the displacement plunger *m*. The mainspring of the clock has been removed and it is driven by the weight of the plunger, the gear-train and escapement serving to regulate the motion. The volume rate of feed of the fuel is determined by the clock rate, the diameter of the drum *o* and the cross-sectional area of the plunger *m*. The volume of fuel supplied multiplied by its specific gravity or, more correctly, by its density at the existing temperature, gives the rate of feed in terms of weight.

Operation

With the evaporator element *a* in a bath at the desired temperature, and the displacement plunger *m* at the top of the reservoir *k* as shown, the fuel, the specific gravity of which is known, is poured into the reservoir *k* through the filling tube. The apparatus is set to deliver a definite volume, say 3 cc. per min. From the specific gravity of the fuel and its volume rate of feed, the weight of air required to give the desired air-fuel

[10] See The Journal, April, 1926, p. 393.

mixture is calculated and the air-flow is set for this rate. The required head on the manometer i is read from a calibration curve or is calculated from the formula $M = K\sqrt{(hp)}$ where M is the rate of air-flow in grams per minute, K is a constant for the particular orifice, h is the difference in level of the water in the two arms of the manometer i expressed in centimeters, and p is the density of the air at the temperature and pressure of the low side of the orifice.

The air-flow and the fuel-flow are started and, when liquid begins to collect in the graduated tube d, readings of rate of collection are made. This rate should become constant within a few minutes when the final observation of rate of collection is made. The percentage evaporated by volume, is then $[1 - (\text{rate of collection} \div \text{rate of feed})] \times 100$. If desired, the density of the unevaporated liquid can be determined, and the percentage evaporated by weight can be calculated. This process can be repeated as desired, at various temperatures and air-fuel ratios.

The size of tube d is selected to give the desired pre-

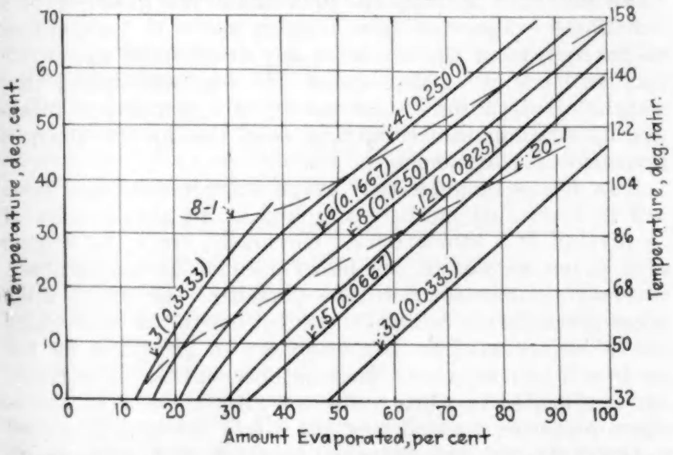

FIG. 4—DISTILLATION DATA IN VARIOUS AIR-FUEL RATIOS FOR THE SAME GASOLINE, NO. 6, SHOWN IN FIG. 3

The Whole Numbers on the Curves Indicate the Parts by Weight of Air to One Part of Fuel, and the Decimals in Parentheses Indicate the Corresponding Parts of Fuel to One Part of Air

cision. A 1-cc. or a 5-cc. tube is desirable for work near the end-point, and a larger tube is conveniently used for conditions of partial evaporation. To eliminate drainage errors when the tube is filling rapidly, the time should be noted when the meniscus passes some convenient index-line on the tube. A definite volume, 1, 5 or 10 cc., is subsequently drained out into an accurate graduate or calibrated flask and the time noted when the meniscus again passes the index line. The interval accurately represents the time required for the accumulation of the measured volume.

EXPERIMENTAL RESULTS

In general, it is desirable that vapor and temperature equilibrium conditions be realized in the apparatus if results are to be truly indicative of the volatility characteristics of the fuel. These conditions were tested by making observations of the percentage of fuel evaporated at various rates of flow at the same temperature. Independence of the percentage evaporated of the rates of air and of fuel feed, the ratio being kept constant, appears to be sufficient evidence that equilibrium has been reached. This test applied to helices of various lengths and diameters led to the use of the dimensions stated.

With this apparatus, increasing the rate of feed from 2 to 3 cc. per min. produces no detectable change in the percentage evaporated near the end-point, and a farther

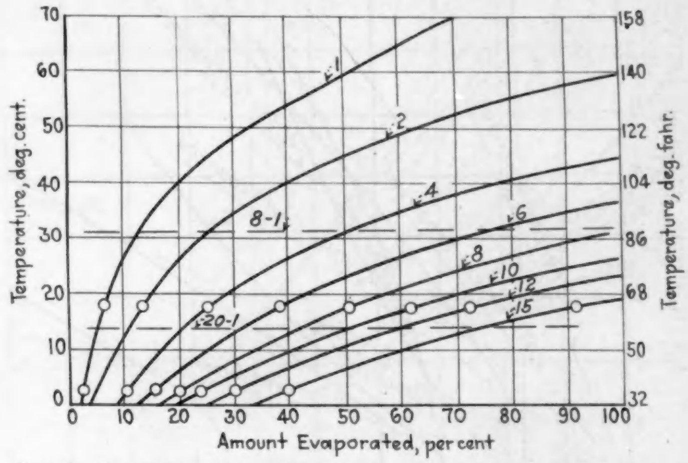

FIG. 5—PLOT FOR A PURE HYDROCARBON, OCTANE, CORRESPONDING TO THAT IN FIG. 4

Any Air-Fuel Mixture Supplied Will Give, at Atmospheric Pressure, a Resultant 20 to 1 Mixture at 14.0 Deg. Cent. (57.2 Deg. Fahr.). At a ½-Atmosphere Pressure, a Resultant 20 to 1 Mixture Can Be Obtained at 3 Deg. Cent. (37.4 Deg. Fahr.)

increase to 4 cc. per min. brings in a slight decrease, less than 1 per cent in the amount evaporated. Increased air and fuel rates call for an increased rate of heat transfer; in addition, the increased air-velocity tends to sweep the fuel through the helix more rapidly, thus tending further to reduce the opportunity for heat transfer.

The results reported here were, for the most part, obtained with the 3-cc. fuel-rate and probably are within 1 or 2 per cent of the truth. The reproducibility of the results is within 1 per cent; that is, check results on different runs agree within better than 1 per cent as to the percentage evaporated.

The desirable feature of this method of test is that the fuel is evaporated under essentially the conditions of utilization in the engine; that is, at low vapor-concentrations in the presence of relatively large volumes of air. In addition, direct measurement of the weight of fuel evaporated avoids the necessity of calculations involving vapor-pressures and molecular weights which require measurement of these quantities. The test procedure and the application of test results to the relative

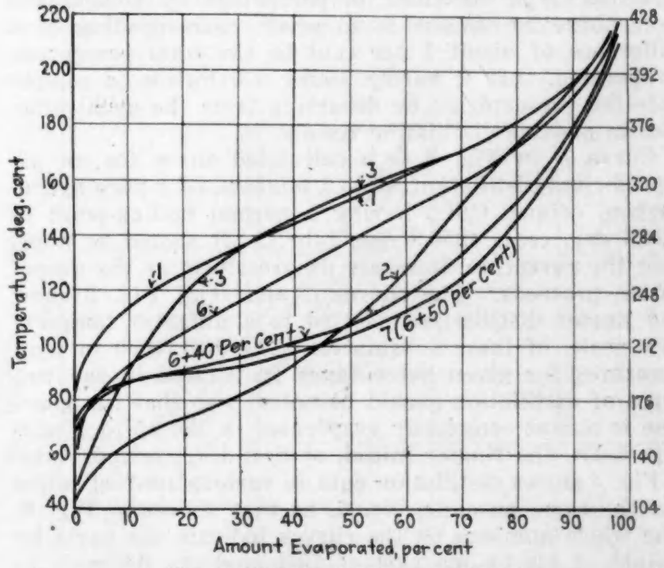

FIG. 6—ENGLER DISTILLATION CURVES

These Curves Are for the Fuels for Which Equilibrium Air-Distillation Data Are Given. Fuels 1, 2 and 3 Are Special Gasolines Blended for the Fuel-Volatility Tests. Fuel 6 Is a Commercial Gasoline Purchased on Federal Specifications. Fuel 6+40 Per Cent Is a Blend of Fuel 6 with 40 Per Cent of 90-Per Cent Benzol. Fuel 7 Is a Blend of Fuel 6 with 50 Per Cent of the Benzol

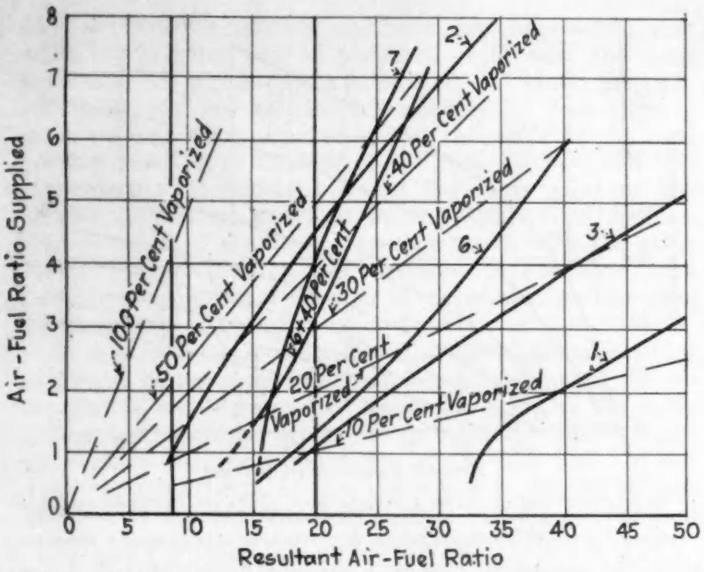

FIG. 7—EQUILIBRIUM AIR-DISTILLATION CHARACTERISTICS OF THE FUELS

These Are for 0 Deg. Cent. (32 Deg. Fahr.) in Various Air-Fuel Ratios Supplied. The Ratios Are Plotted as Ordinates against the Air-Fuel Vapor Ratios Which Result from the Partial Evaporation of the Fuel as Abscissas. Points to the Left of the Ordinate Corresponding to the 20 to 1 Resultant-Mixture and to the Right of the Ordinate Corresponding to the 8 to 1 Resultant-Mixture Are Presumably in the Explosive Range

rating of fuels are reasonably simple and direct because the test results are dependent only on the volatility characteristics of the fuel which are definite physical constants.

In Fig. 3, the curve *A* represents the air equilibrium-distillation of an average gasoline fuel in the presence of 15 times its weight of air, and this illustrates well the general characteristics of such distillation curves. It should be noted that the curve from 30 or 40 to 95 or 100 per cent is practically a straight line, and that the lower end breaks away rather sharply. The upper end may be straight or may droop slightly below or rise above the straight line as indicated by the dotted lines, depending upon the fractionating equipment used in production.

All the curves given in this paper are plotted on a percentage-by-volume basis in accordance with common practice. The difference in percentage by volume and percentage by weight is so small, corresponding to a difference of about 1 per cent in the total percentage evaporated, that it hardly seems worthwhile to complicate the presentation by departing from the usual practice in plotting distillation results.

Curve *B* in Fig. 3 is a calculated curve for an air equilibrium-distillation, 15 to 1 mixture, of a pure hydrocarbon, octane, C_8H_{18}, having a normal boiling-point of 124.6 deg. cent. (256.3 deg. fahr.). It should be noted that the curvature decreases progressively as the evaporation proceeds. The curves *C* and *D* of Fig. 3 show the Engler distillations, plotted to a different temperature scale, of these substances. The difference in temperatures for given percentages evaporated in the two types of distillation should be noted, also that the gasoline is almost completely evaporated in the 15 to 1 mixture below the Engler initial, or first-drop, temperature.

Fig. 4 shows distillation data in various air-fuel ratios for the same gasoline, No. 6, as that shown in Fig. 3. The whole numbers on the curves indicate the parts by weight of air to one part of fuel, and the decimals in parentheses indicate the corresponding parts of fuel to one part of air. Thus 15(0.0667) indicates the curve for a 15 to 1 air-fuel mixture or a 0.0067 to 1 fuel-air mixture supplied. The resultant air-fuel vapor mixture is dependent upon the percentage evaporated; thus, 75 per cent evaporated in a 15 to 1 air-fuel mixture supplied corresponds to a 15 to 0.75 = 20 to 1 resultant air-fuel vapor mixture.

The lower dotted line marked 20—1 and crossing the distillation curves at an acute angle is drawn through points of 20 to 1 air-fuel vapor mixtures resulting from the partial evaporation of the fuel in the various air-fuel mixtures supplied. Points on the curves above this line represent resultant mixtures richer than 20 to 1. In like manner, the upper dotted line is drawn for a resultant 8 to 1 air-fuel vapor mixture. Assuming that these ratios mark the rich and the lean limits of explosive mixtures, it is seen that the portion of the plot between these lines represents the operating range in the engine. For instance, an 8 to 1 mixture at 70 deg. cent. (158 deg. fahr.) would be barely lean enough to fire, and a 3 to 1 mixture at 3 deg. cent. (37.4 deg. fahr.) would give a resultant mixture barely rich enough to fire. This is based on the assumption that the evaporation takes place with air at atmospheric pressure.

As has been pointed out previously, the quantity of a substance evaporated into a given space is independent of the weight of the air or of any other inert gas which may be present in that space. It was also stated that weight of air is here used purely as a convenient measure of volume, understanding that the air is under a pressure of 1 atmosphere.

Now let us consider that evaporation takes place from a 3 to 1 air-fuel mixture supplied at an air-pressure of ½ instead of 1 atmosphere. Obviously, since the volume of a given weight of air is, at a constant temperature, inversely proportional to the pressure, the evaporation takes place into a *volume* of air equivalent to that which would be occupied at 1 atmosphere of pressure by the air in a 6 to 1 mixture. Making observations of percentage evaporated in a 3 to 1 air-fuel mixture at a ½-atmosphere pressure, we find that the 3 to 1 curve is displaced to the right and superimposed on the 6 to 1 atmospheric curve. This follows from the fact that evaporation takes place into exactly the same volume in both cases. This relation makes it easy to construct a distillation plot for lower pressures, having given the data for distillation in various weight ratios at atmospheric pressure. Fig. 4 can be transposed into a ½-atmosphere plot by dividing the air weights by 2; thus, 3 becomes 1½, 4

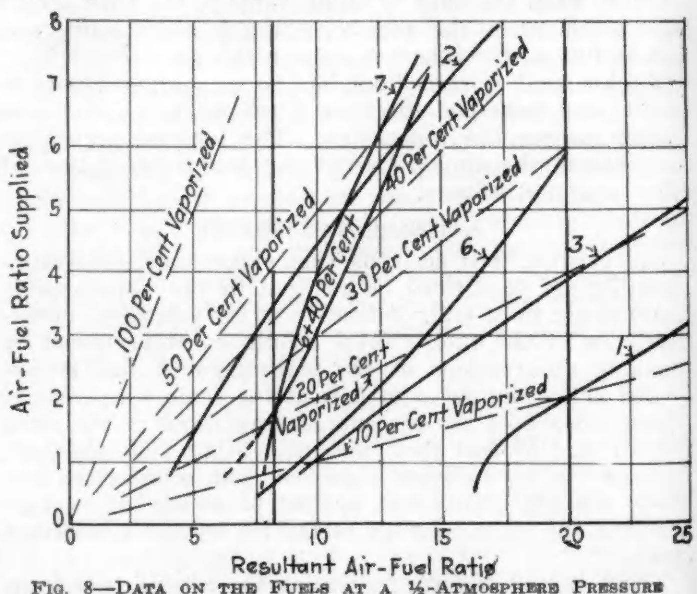

FIG. 8—DATA ON THE FUELS AT A ½-ATMOSPHERE PRESSURE

These Data Were Obtained at 0 Deg. Cent. (32 Deg. Fahr.). On This Reduced-Pressure Basis, No. 1 Fuel Shows a 20 to 1 Resultant-Mixture from a 2 to 1 Mixture Supplied

becomes 2, 6 becomes 3, and the like. The fuel weights, in parentheses, are doubled to correspond. With this change, a corresponding change must be made in the location of the constant-mixture lines.

Fig. 5 represents a corresponding plot for a pure hydrocarbon, octane, and it is seen that the constant resultant-mixture lines are perpendicular to the temperature axis, indicating that no change in resultant-mixture richness can be secured below 100 per cent evaporated by supplying an excess of a pure compound. However, the effect of reduction of air-pressure is similar to that for a gasoline. The circles represent the 20 to 1 and the 8 to 1 mixture lines for a ½-atmosphere pressure.

From Fig. 5 it is seen that a 3 to 1 air-fuel mixture supplied will give, at atmospheric pressure, a resultant 20 to 1 mixture at 14 deg. cent. (57.2 deg. fahr.). At ½-atmosphere pressure, however, reading on the 6 to 1 line, the temperature corresponding to a 20 to 1 resultant mixture, the lower line of circles, is only 3 deg cent. (37.4 deg. fahr.). The effect of reduction of air-pressures on the mixture richness is obvious. This effect is solely due to the fact that the reduced air-pressure results in a correspondingly reduced weight of air per unit of volume and, for a given resultant air-fuel ratio, a proportionately smaller quantity of fuel must be vaporized. The resultant mixture, whether of a gasoline or a pure hydrocarbon, will supply only one-half the amount of energy on combustion as would a corresponding mixture-ratio at a pressure of 1 atmosphere.

Prediction of Engine Performance

The prediction of the performance of the actual engine from these volatility data involves the introduction of other factors, some of which may be general, applying to the majority of present-day engines, and others specific, such as a special engine or induction system. One of the general questions relates to the attainment of vapor equilibrium in the engine. This is largely a matter of heat transfer to the liquid fuel and involves a time factor. Obviously, this factor of degree of equilibrium should not be included in a test method, but should be evaluated as well as may be in the application of test results. In this conection it can be said that the heat of vaporization of the fuel, that is, the quantity of heat required to vaporize unit mass of the fuel, directly affects the *rate of attainment* of vapor equilibrium under a given set of operating conditions. Fortunately, the heats of vaporization of petroleum products differ among themselves but slightly; so, this factor can properly be neglected here. However, other substances, alcohols for instance, have heats of vaporization very different from the petroleums and, in a relative rating of petroleum and alcohol fuels, this factor should be taken into account. It does not, however, seem either necessary or advisable to try to set up a test method which evaluates directly the combined effect of volatility and heat of vaporization.

Other general questions relate to the place and conditions of evaporation. Does evaporation take place largely in the manifold, or in the cylinders? What is the prevailing pressure and the effect of compression? Obviously, the answers to these questions do affect not only the predictions of absolute, as contrasted with relative, values regarding actual engine-performance but also the choice of the particular test conditions which best represent the actual conditions of engine utilization of the fuel.

Starting Volatility

In starting an automobile engine at low temperatures it is necessary to supply relatively large quantities of

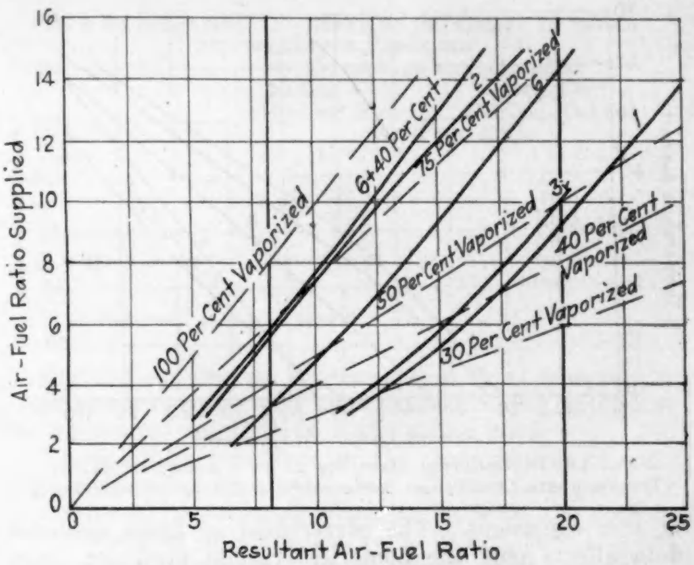

Fig. 9—Analogous Data to Those in Fig. 7
The Data Were Obtained at 35 Deg. Cent. (95 Deg. Fahr.) and Indicate That the Differences in Volatility Are Less at the Higher Temperatures with Larger Percentages Evaporated

fuel in order that a sufficient quantity of the more volatile components of the fuel which will vaporize under the starting conditions will be available to form an air-fuel vapor-mixture which will explode. To be enabled to speak in concrete terms, the following data are assumed:

(1) A 20 to 1 air-fuel mixture (0.05 fuel-air) is the leanest which can be ignited in the engine
(2) This leanest explosive mixture is independent of the total pressure on the charge within the range encountered in engine operation
(3) Evaporation takes place in the manifold and cylinders at a pressure represented by the pressure in the manifold
(4) A 2 to 1 air-fuel mixture (0.5 fuel-air) is the richest which it is feasible to supply, short of direct priming, for starting

Assumptions (1) and (2) probably are essentially correct, but assumptions (3) and (4) may be open to question. It is possible to supply almost any air-fuel mixture by suitable construction, of course, but it may not be expedient to exceed a certain richness on account of choking the engine with an over-rich mixture after one

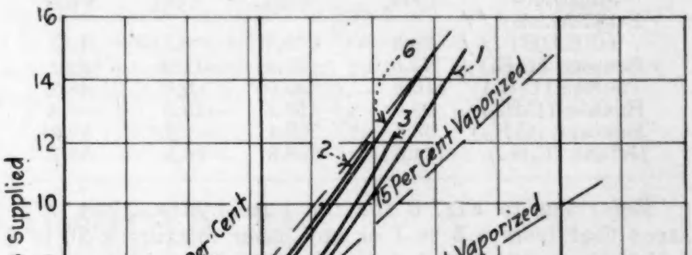

Fig. 10—Similar Data to Those of Fig. 9
Taken at 60 Deg. Cent. (140 Deg. Fahr.) the Data Indicate Still Closer Approach to Equality

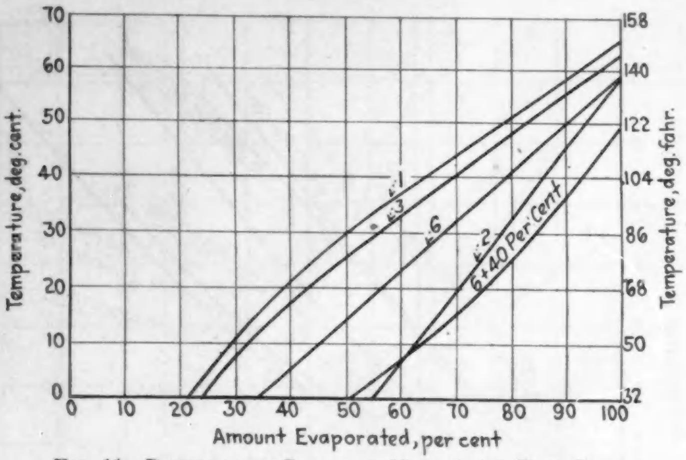

FIG. 11—DISTILLATION DATA FOR 15 TO 1 AIR-FUEL RATIOS
The Data Are Obtained at Atmospheric Pressure for Five Fuels

or two explosions. The correctness of these assumed data affects only the numerical results predicted from the volatility-test data; any other suitable data could be assumed regarding operation without effect upon the method of interpretation.

With a 3 to 1 air-fuel mixture supplied, it is apparent that 15 per cent of the fuel must be evaporated to give a 3.00 to 0.15 = 20 to 1 resultant air-fuel vapor mixture. Referring to Fig. 4, it is seen that 15 per cent of the fuel is evaporated in a 3 to 1 mixture at 1 atmosphere pressure at 2 deg. cent. (35.6 deg. fahr.), neglecting here the difference between percentage by weight and percentage by volume. However, engines usually are started with the throttle almost closed, giving a reduction of pressure in the manifold; so, if we consider the ½-atmosphere condition, the temperature is —10 deg. cent. (14 deg. fahr.), 15 per cent on the 6 to 1 line. This extrapolation of the 6 to 1 curve in Fig. 4 is, of course, of doubtful accuracy, but it serves here only to illustrate the point regarding the effect of reduced pressure on resultant-mixture richness.

TABLE 1—TEMPERATURES AT WHICH SOME PURE HYDROCARBONS GIVE A 20 TO 1 MIXTURE

	Normal Boiling-Point		Temperature To Give 20 to 1 Mixture	
Substance	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.
Ethyl Alcohol (C_2H_5OH)	78.5	173.3	9.5	49.1
Benzene (C_6H_6)	79.6	175.3	—11.0	12.2
Toluene (C_7H_8)	110.5	230.9	9.0	48.2
Hexane (C_6H_{14})	69.0	156.2	—23.0	—9.4
Heptane (C_7H_{16})	98.4	209.1	—1.0	30.2
Octane (C_8H_{18})	124.6	256.3	14.5	58.1

Referring to Fig. 5 for the pure hydrocarbon, it is seen that from a 3 to 1 or any other mixture a 20 to 1 mixture results at 14 deg. cent. (57.2 deg. fahr.) at 1 atmosphere total pressure. At a ½-atmosphere pressure, the temperature is 3 deg. cent. (37.4 deg. fahr.). Thus, starting with a pure substance differs from starting with gasoline in that enrichment cannot be secured by an excess supply of fuel.

The temperatures at which some pure hydrocarbons will give 20 to 1 resultant air-fuel mixtures at atmospheric pressure are shown in Table 1.

The data in Table 1 show why the addition of considerable quantities of benzol to gasolines, although improving the total volatility, often does not have a desirable effect on starting characteristics at low temperatures, since part of the more volatile compounds, hexanes and pentanes, are replaced by the less volatile benzol (benzene and toluene). The undesirable effect should be especially marked where such blends are made up to have the same average volatility as the unblended fuel.

Fig. 6 shows the Engler distillation-curves for the fuels for which the equilibrium air-distillation data are given in this paper. Nos. 1, 2 and 3 are special gasoline blended for the fuel-volatility work[11] described at the 1926 Annual Meeting of the Society. Note that Fuels 1 and 3 are similar above the 25-per cent point with Fuel 2 decidedly lower than either up to the 85-per cent point, beyond which the three curves are practically identical. Fuel 6 is a commercial gasoline purchased on federal specifications in quantity for engine work at the Bureau of Standards. Fuel 6 + 40 per cent is a blend of Fuel 6 with 40 per cent of 90-per cent benzol, and Fuel 7 is a blend of Fuel 6 with 50 per cent of the benzol.

Fig. 7 shows the equilibrium air-distillation characteristics of these fuels at 0 deg. cent. (32 deg. fahr.) in various air-fuel ratios supplied. These ratios are plotted as ordinates against the air-fuel-vapor ratios, which result from the partial evaporation of the fuel, as abscissas. Points to the left of the ordinate corresponding to the 20 to 1 resultant-mixture and to the right of the ordinate corresponding to the 8 to 1 resultant-mixture are presumably in the explosive range.

The dotted lines radiating from the zero of coordinates represent various percentages evaporated. The order of the fuels as compared with the lower end, or 10-per cent point, of the Engler distillation curve should be noted. The crossing of curves for Fuel 2 and Fuel 6 + 40 per cent on the two plots in the region of 50 per cent evaporated, and the incipient merging of Fuels 6 and 3 at 5 per cent or 10 per cent evaporated are of interest. The sharp drooping of Fuel 1 below the 3 to 1 air-fuel ratio supplied is of especial interest. This fuel will not give an explosive mixture with air in a glass bomb[12] as described at the 1926 Annual Meeting of the Society, at 0 deg. cent. (32 deg. fahr.), with any supplied mixture-ratio. The leanest resultant mixture which would fire in this type of bomb is about 29 to 1 or 30 to 1 air-fuel vapor. The trend of the curve for Fuel 1 indicates that a 30 to 1 air-fuel vapor mixture could not be obtained with this fuel at 0 deg. cent. (32 deg. fahr.) atmospheric pressure, with any air-fuel ratio supplied. Further, the engine used in the starting tests could not be started at 0 deg. cent. (32 deg. fahr.) with this fuel. As previously mentioned, volatility data at an air-pressure of 1 atmos-

[11] See THE JOURNAL, February, 1926, p. 147.
[12] See THE JOURNAL, April, 1926, p. 393.

TABLE 2—SATURATION TEMPERATURES FOR VARIOUS AIR-FUEL RATIOS

	Saturation Temperatures										Engler Distillation					
	15 to 1		12 to 1		10 to 1		8 to 1		4 to 1		80 Per Cent		85 Per Cent		90 Per Cent	
Fuel No.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.
1	65.0	149.0	68.0	154.4	70.0	158.0	76.0	168.8	94.0	201.2	183.0	361.4	188.0	370.4	197.0	386.6
2	59.0	138.2	62.0	143.6	63.0	145.4	67.0	149.0	79.0	174.2	174.0	345.2	185.0	365.0	197.0	386.6
3	63.0	145.4	67.0	152.6	69.0	156.2	76.0	168.0	97.0	206.6	183.0	361.4	188.0	370.4	197.0	386.6
6	59.0	138.2	63.0	145.4	64.0	147.8	68.0	154.4	79.0	174.2	163.0	325.4	181.0	357.8	191.0	375.8
6+40	50.0	122.0	52.5	126.5	54.0	129.2	58.0	136.4	70.0	158.0	155.0	311.0	167.0	332.6	180.0	356.0

phere can be converted readily into data corresponding to other total pressures.

Fig. 8 represents the data on these fuels at 0 deg. cent. (32 deg. fahr.) and a ½-atmosphere pressure. This transformation is easily made here by dividing both co-ordinate scales by 2 and shifting the 20 to 1 and the 8 to 1 resultant air-fuel vapor ordinates to correspond. The *relative positions of the curves are not changed.* On this reduced-pressure basis No. 1 fuel shows a 20 to 1 resultant-mixture from a 2 to 1 mixture supplied at 0 deg. cent. (32 deg. fahr.) and a 20 to 1 mixture probably would barely result from a very large supply of fuel, priming, at a pressure of about 0.65 atmosphere.

Space will not be taken here to point out the correlations between the volatility data and the engine-starting tests previously referred to except to state that fuels numbered 1, 2, 3, 6, and 7 are identical with those used in the engine tests. It is seen from these data, in Fig. 7, that the relative rating of fuels depends upon the air-fuel ratio supplied, as well as upon the temperature. Possibly 0 deg. cent. (32 deg. fahr.) is not a sufficiently low temperature to give the ultimate rating as to starting performance. Certainly not, except for such fuels as No. 1, if the air-fuel ratio is to be very small, as in priming. Probably, however, for operations on the choke, the 4 to 1 ratio, corresponding to 2 to 1 at a ½-atmosphere pressure, would give a very fair indication of relative starting performance.

Operating Volatility

The data so far presented indicate rather wide difference in the starting performance of these fuels. Fig. 9, showing data obtained at 35 deg. cent. (95 deg. fahr.) analogous to those shown in Fig. 7 for 0 deg. cent. (32 deg. fahr.), indicates that the differences in volatility are less at the higher temperatures with larger percentages evaporated; and Fig. 10, showing data obtained for 60 deg. cent. (140 deg. fahr.), indicates still closer approach to equality. Fig. 11 shows distillation data for 15 to 1 air-fuel ratios at atmospheric pressure from these five fuels. The region above 95 per cent evaporated has not been examined minutely for all the fuels; however, it seems improbable that the departure from the straight line in this region would be sufficient to affect the saturation temperature appreciably. Table 2 presents saturation temperatures for various air-fuel ratios, together with some points on the Engler distillation curve.

Sufficient data are not yet available to justify an attempt to show correlation or lack of correlation between Engler and equilibrium air-distillation data; however, in a general way, especially as regards starting volatility, the agreement seems to be surprisingly good.

Saturation temperatures, or the temperatures of complete evaporation in the air-fuel mixture, are probably indicative of the dilution characteristics of the fuel in that a lowering of say 5 deg. cent. (9 deg. fahr.) in the saturation temperature should permit engine operation at a correspondingly lower temperature for the same dilution. In this connection it should be remembered, however, that operation just above the dry-point cannot be expected to eliminate dilution totally on account of the lowering of the vapor-pressure of the fuel by solution in the oil-film. However, as it has been shown by R. E. Wilson and E. P. Wylde[13] that the solubility of petroleum hydrocarbons is practically the same for all the lubricants generally used, this solubility effect does not enter into the relative comparison of fuels.

Summary

The equilibrium air-distillation seems to offer a direct and relatively simple means of measuring the volatility of motor fuels under a variety of conditions. Volatility data probably will be of immediate interest in connection with studies of engine starting and performance. Possibly such data may be of value also in indicating the most advantageous use of blending stocks to produce a fuel of desired performance as regards volatility.

The operating volatility of a fuel can be expressed in terms of the percentage vaporized, 90 to 100 per cent, in say a 15 to 1 air-fuel mixture at some temperature near the end of the air-distillation range, say at 55 deg. cent. (131 deg. fahr.); and the starting volatility in terms of the percentage vaporized in some low air-fuel ratio, say 4 to 1 at some low temperature such as 0 deg. cent. (32 deg. fahr.). Ratings on this basis of the fuels here discussed are shown in Table 3.

TABLE 3—OPERATING AND STARTING VOLATILITY IN TERMS OF PERCENTAGE VAPORIZED

Fuel No.	Percentage Evaporated at 55 Deg. Cent. (131 Deg. Fahr.), Air-Fuel Ratio 15 to 1	Percentage Evaporated at 0 Deg. Cent. (32 Deg. Fahr.), Air-Fuel Ratio 4 to 1
1	86.0	10.0
2	97.0	40.0
3	89.5	15.0
6	94.5	16.5
6 + 40	100.0[a]	23.5
7	...	24.3

[a] At 50 deg. cent. (122 deg. fahr.).

[13] See *Industrial and Engineering Chemistry*, August, 1923, p. 801.

FEDERAL-AID HIGHWAYS

In 1916 Congress passed the first Federal-aid highway act, appropriating $5,000,000 to start the job of assisting the States in building a nationally connected system of highways. Since then Congress has authorized appropriations totaling $615,000,000 up to July 1, 1926, of which approximately $490,000,000 has been appropriated and some $420,000,000 paid to the States. To date more low-type roads—sand, clay and gravel—have been built with the assistance of Federal funds than all the higher types of surface put together.

Last year less than 2½ cents of each Federal dollar was devoted to highways, $92,000,000 being paid to the States. During the same period $304,000,000, or more than three times as much as was required to meet Federal aid, was collected by the States in special fees, such as motor-vehicle registration fees and gasoline taxes. Who is paying the highway bill? Several States reduced general-property taxes last year principally because of increased motor-vehicle revenues that decreased or eliminated the general State levy for highway purposes. This is notably the case in Wisconsin and North Carolina. Local roads are largely financed from local tax levies, and economists generally agree that this is sound, except where the State does not assume its full obligation for a state-wide system of highways. Eighty per cent of the motor vehicles of the country pay gasoline taxes ranging from 1 to 5 cents per gal. South Carolina leads the list with a 5-cent tax. North Carolina, Nevada and Arkansas follow closely with a 4-cent tax; one State has a 3½-cent tax; 15 others, a 3-cent tax; 1, a 2½-cent tax; 19, a 2-cent tax, and 4, a 1-cent tax.—A. J. Brosseau.

Aerial Navigation

By Bradley Jones[1]

Dayton Section Paper

ABSTRACT

TRANSPORTATION by aircraft is of value chiefly because of the shortening of time between places of departure and arrival. This can be accomplished by shortening the distance traveled as well as by increasing the rate of speed. A slow airplane can, by flying a direct line and taking advantage of favoring winds, beat a fast airplane that travels a tortuous route and combats head winds. Navigation is therefore of prime importance in aircraft operation, as it implies flying the most direct course and selecting the altitude that has the most favorable meteorological conditions.

Navigation, whether in the air or on the water, presents the problems of ascertaining one's geographical position and of maintaining a given direction. The former is simplified if the direction and rate of movement are known. The similarity and the differences between the navigation of water-craft and aircraft are pointed out. On long flights over water or where landmarks do not exist, the position of an aircraft is ascertained by sextant observations of the sun or stars, when possible, as in the case of a ship. Over land, the aircraft navigator determines his position by natural features of the landscape and by cities. Even in cloudy weather occasional glimpses of the earth usually can be obtained through rifts or holes in the clouds.

Drift is the deviation from a straight course due to movements of the air; in a ship it is due to ocean currents and side pressure of the wind on the hull and superstructure. Ocean currents are practically constant and their direction and rate of movement are known. Air currents vary greatly in both direction and velocity; they also vary with altitude and change more quickly when the aircraft is traveling in a north-and-south direction than when it is traveling in an east-and-west direction. The extent of drift of an aircraft is determined by landmarks or, when over large expanses of water or ice fields, by sextant observations or by dropping smoke bombs or flares. Several instances of very accurate navigation above clouds and over the ocean are cited.

Some of the peculiarities of navigation on the polar flights in the spring of 1926 are pointed out. If one starts from anywhere on earth and flies due north he will reach the North Pole, barring mishaps; also, if he starts from anywhere and flies any northerly course between 89 and 271 deg. of the compass, he will eventually reach the pole by a spiral course. The due north distance from the equator to the pole is 6300 miles, while that of an 89-deg. course is 350,000 miles. At the pole all directions are south. To return to his base, the aviator must determine the degree of longitude he will follow. Two airplanes leaving the pole, one for Spitzbergen and the other for Point Barrow, will both fly due south but in diametrically opposite directions.

The magnetic compass is of doubtful value in the Arctic regions, as the magnetic and geographic poles are far apart. Moreover, a magnetic needle points straight down at the magnetic pole. It is also affected much more by the iron and steel in the aircraft as the magnetic pole is approached. For these reasons, a sun compass is of great value in the polar regions.

A straight course by compass is not always the shortest distance between two places. The round-the-world fliers, who flew from Seattle northward along the Aleutian Islands and southward to Japan and China, followed a shorter route than if they had flown directly across the Pacific Ocean. The Air Mail route from New Brunswick, N. J., northwesterly to Cleveland and Chicago, west to Elko, Nev., and southwesterly to San Francisco is shorter than a direct line from New Brunswick to San Francisco.

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THE chief, if not the sole, value of aircraft transportation lies in its speed. Aircraft should rank first as carriers where quickness of delivery is the prime essential. Anything that expedites arrival at destination, without lessening the reliability of the service, should be of interest to aeronautical engineers.

Great efforts have been made by designers to increase the speed of airplanes; it would appear that almost all research and experimental work was for this end. Few engineers seem to realize that the time of flights can be shortened by having the airplane travel fewer miles, as well as by having it travel faster. Elapsed time of flight between points of departure and destination is the proper criterion. A slow airplane can, by flying a direct line and taking advantage of favoring winds, beat a fast airplane that travels a circuitous route and combats head winds.

Aerial navigation is the art of utilizing all possible aids to enable an aircraft to accomplish its mission efficiently under adverse, as well as favorable, conditions. This implies not merely flying the most direct course but selecting the altitude that has the best meteorological conditions, such as visibility, favorable winds and other important factors.

Navigation, whether aerial or nautical, presents the two problems of (*a*) ascertaining one's geographical position and (*b*) maintaining a direction. If the direction of movement is known, the first problem is greatly simplified. The process of navigating a ship at sea is roughly as follows: Position of the ship is ascertained by observations of the sun or stars. Allowance is made for estimated ocean currents and expected drift due to wind, and a course is set that should bring the ship to its destination. A log registers the number of miles the ship travels ahead through the water. A position can be deduced at any time by reading the log and assuming that the registered distance has been traveled along the set course except for drift and current. This deduced reckoning or, as it is usually termed, "dead-reckoning," is liable to considerable error. Whenever a position is found by astronomical observation, it is assumed to be correct and the discrepancy between the dead-reckoned position and that found by sextant observation is usually attributed to "current." This "current" includes not only the difference in position due to flow of the water but also the errors due to imperfect steering, improper allowance for compass error and drift and inaccurate logging.

In the air, navigation by dead-reckoning is extremely difficult when out of sight of land, because of the variability of air currents, or winds. At sea, the movements of the water are well known and have been charted. Ocean currents are due principally to trade-winds and are practically constant. The movement of the swiftest current, the Gulf Stream that flows between Florida and

the Bahamas, is only 5 m.p.h. Air currents vary from hour to hour and differ at different altitudes. Winds of 40 to 50 m.p.h. are not uncommon, and much higher velocities may be encountered.

How Ship and Airplane Drift Differs

Much misconception has arisen through the use of the term "drift" to designate the extent to which an airplane is carried off its course by wind. At sea, drift or "leeway" refers to the distance a ship is blown sideways through the water by the force of the wind on the hull and superstructure above the water. An airplane, which is wholly in the air and moves forward under the action of its engine and propeller, never moves sideways through the air; if the air moves, the airplane is carried with it and describes a path with respect to the ground that differs from the direction of its heading.

Drift can be measured from an airplane on most cross-country flights by any of several sighting devices. If the angle of drift is known, the course of the airplane is altered to result in "crabbing" into the wind so that a correct course over the ground is flown. Even on cloudy days there are usually rifts or holes in the clouds through which sufficient glimpses of the ground can be obtained for measuring the drift. Weather conditions change much more quickly in a north-and-south direction than in an east-and-west direction; therefore, when flying north or south it is wise to obtain drift measurements about every 50 miles, whereas, when flying east or west, a measurement every 75 or 100 miles is usually often enough.

Drift measurements from the airplane are impossible when clouds entirely obscure the ground. Various plans that involve the use of a longitudinal wire which cuts the earth's lines of force or of a ball rolling on a flat plate have been proposed for taking such measurements, but none of these schemes has been made practical as yet.

Major Blair, of the Signal Corps, has devised a method of measuring wind velocities above clouds from a station, and if the wind velocity is radioed to aviators in the air the information can be used to correct their courses. Without this definite information, only approximations can be made. The turning of winds with altitude is known in a general way, and by studying weather maps a rough idea can be obtained of the probable winds that will be encountered. An example of this is given by a flight of Lieutenant Barksdale, of the engineering division of the Army Air Service, in March, 1924. When he left New York City for Dayton, a 50-mile wind necessitated his crabbing 30 deg. into the wind. As he crossed New Jersey he found patches of clouds, and when he entered Pennsylvania the clouds were in two solid layers. He flew for 4 hr. at a constant altitude with absolutely no sight of the earth. A study of the weather map before starting showed that the north wind on Long Island probably would back to the northwest over Pennsylvania. Reasoning that, coming from this direction, the wind would have less effect on his course, Lieutenant Barksdale arbitrarily altered his course and crabbed less and less as he flew onward. When he decided that he should be nearing Dayton, he spiraled down through the clouds and found himself only about 12 miles north of his course.

The personnel of McCook Field have made several other noteworthy flights without the aid of landmarks. The flights were made above clouds but on most of them openings in the clouds at intervals of about 100 miles enabled the drift to be measured. Lieutenant Hagenberger's flight to Boston was an especially good example of aerial navigation under adverse conditions. When he left Dayton the sky was filled with cloud patches, which increased as the airplane flew eastward. A brief glimpse of the ground near Columbus showed the stadium of the Ohio State University to the south, which assured him that he was on his course. Another sight of the earth an hour later revealed a town on a river, which was assumed to be Beavertown on the Ohio. Then the blanket of clouds again hid the ground. The entire State of Pennsylvania was crossed and finally, when it was expected that the airplane should be nearing the Hudson River, a descent was made through the clouds. Fortunately, the clouds were not closer to the ground than 3000 ft. and flight was continued under them. The Hudson was crossed 5 min. later, and the first real landmark check was the sighting of the city of Hartford which was on the direct course to Boston.

Drift Measurement and Sextant Observations

An aviator, when flying over land, needs a good compass to enable him to fly a straight course, and he must be kept informed of his drift so that this straight course shall be the correct path to his destination. Without both a reliable compass and drift knowledge, the aviator must follow railroads, highways and rivers and consequently must fly a devious course. A knowledge of direction and drift are also necessary when flying over water. Since objects on which to sight are absent, the airplane carries smoke bombs or flares, which are dropped whenever a drift measurement is desired.

Sextant observations are made in much the same way as from ships, and if the airplane is low enough for the sea horizon to be used, the same degree of accuracy is obtainable. An artificial horizon is used when clouds or haze hide the true horizon, but the accuracy of these "shots" is much less than that obtained with the true horizon, although it probably is of a higher order than is the accuracy of dead-reckoning.

The first non-stop crossing of the Atlantic Ocean by Alcock was made successful by the sextant observations of his navigator, Brown. The flight of Commander Saccadura Cabral was even more noteworthy, as his objectives were tiny islands, but, owing to the remarkable astronomic observations of the navigator, Admiral Gago Continho, they were uniformly successful in reaching their destinations. In the round-the-world flight, all of the over water hops were made through fog so dense that sextant observations were impossible. The navigation was entirely by dead reckoning, as no radio was carried. On the recent flights of Commander Franco, of the Spanish Navy, and Commander Rogers, of the United States Navy, dependence was placed on radio direction-finding.

Some Peculiarities of Polar Navigation

The polar flights in the spring of 1926 presented some peculiar problems in navigation. Everyone probably realizes that if one starts from any point on the earth and flies due north, he will reach the North Pole, barring mishaps. It is not so commonly appreciated that, starting from any point and flying any northerly course between 89 and 271 deg. by compass, the North Pole will be reached eventually by way of a spiral course. Starting from the equator and flying due north, the pole is reached after traveling 6300 miles; but if one starts at the equator and flies continuously an 89-deg. course, he will travel more than 350,000 miles to reach the pole.

At the pole, the question is, What direction shall be flown to return to the base? One should fly south, of course, but since every direction is south, the navigator

must decide which particular south must be flown. If two airplanes leave the pole, one for Spitzbergen and the other for Point Barrow, they start in diametrically opposite directions, yet each will fly south.

A magnetic compass is of doubtful value in the Artic Circle. It points to the magnetic pole but not to the geographic pole, and as the magnetic pole is a short distance north of Hudson Bay, a large variation exists between true north and magnetic north as the high latitudes are reached. In southern Greenland, whence the round-the-world fliers started their hop to North America, the variation was 45 deg. and the compass pointed northwest instead of north. The navigators knew of this error, however and made allowances for it. In regions where no magnetic surveys have been made, some theoretical variations of the compass are assumed.

A more serious difficulty is due to the dip, or inclination, of the needle. At the magnetic pole a freely suspended magnetic needle will point straight down. At Dayton it dips 72 deg. from the horizontal. The horizontal component of the earth's pull gives a compass its directional value. As one nears the magnetic pole, the horizontal force, which is the cosine of the total force, becomes less and less. On every airplane iron or steel affects the compass. Every compass reading is, therefore, a compromise or resultant between the earth's pull and the pull of the iron or steel in the airplane. One may "swing" the airplane at the start of a trip and make a "deviation card" on which is tabulated the effect of the steel of the airplane on different headings. As one flies to a region where the dip is greater as the directional effect of the earth becomes less, the deflecting effect of the steel becomes greater. It is easy to conjecture that regions may be reached where the earth's effect will be completely nullified and the needle will point directly to the engine or other part of the airplane having the greatest magnetic pull. For both of these reasons the sun compass will be of great value in aviation in the Arctic regions.

When the Long Way Round Is Shortest

The aerial navigator, in addition to guiding aircraft in flight, will be called upon to lay out routes. Very little distance is saved on short hops by flying a great-circle course, but on long routes the advantage gained is considerable. North Cape, Norway, is in the same latitude as Point Barrow, Alaska, and if one flies due west from Point Barrow he will arrive at North Cape. The distance that way is 4000 miles. If one flies over the pole, however, the distance is only 2586 miles, a saving of more than one-third of the distance. Tokio is slightly south of the latitude of New York City, and if one starts from New York City and flies a constant course of 0.2 deg. south of west he will arrive at Tokio after traveling 7950 miles. By starting on a north-northwest course and going through Canada and Alaska and then heading southward, the distance is shortened to 6700 miles. This means that refueling stations will be located along this path.

The round-the-world fliers, in going from Seattle to Japan and China, flew northward along the Aleutian Islands chain. This route is actually shorter than if they had been able to cross the Pacific Ocean by way of the Hawaiian and Caroline Islands. San Francisco is more southerly than New York City, but the Air Mail route from New Brunswick, N. J., cuts northerly to Cleveland and Chicago, thence almost due west to Elko, Nev., and finally bends in a southwesterly direction to San Francisco. Although this route probably was chosen because of the desirability of touching certain large cities and of keeping near the Union Pacific Railroad, it is interesting to realize that it is actually shorter than if a constant direction were maintained.

AUTOMOTIVE RESEARCH

(Concluded from p. 124)

The Guide Motor Lamp Mfg. Co. had available for demonstration a car with lamp equipment arranged so that the beam patterns as illustrated in Fig. 8 could be obtained. The specifications for the elementary beam patterns used for building-up these light distributions are given in Table 2.

Another car was provided by Dr. H. C. Dickinson, of the Bureau of Standards. The outer two of the four lights on this car were intended for meeting lights and had a total horizontal spread of 30 deg. The vertical depths of the light distribution were obtained with a lens giving 2-deg. spread. To this had to be added an unusual spread of about 4 deg., the latter amount being due to the filament not being infinitely small and not exactly in the theoretical focus. These lamps were adjusted 2 or 3 deg. below the horizontal.

The two central lights on this car gave an 8-deg. horizontal spread and the same vertical spread as the outer lights. In this case, the lenses were rotated approximately 15 deg. so as to bring the inner ends of the horizontal beams above the outer ends. The two lamps were then aimed outward so that the two beams overlapped at the center and threw less light toward the right and left. When all four lamps were used on this car a triangular distribution of the light was obtained with a horizontal base-line and a bright spot at the top of the triangle.

Councilor Warner Named Assistant Secretary of the Navy

His Message on the Road to Progress in Aviation Defines Need for Cooperation Between Naval Air Service and the Industry

FOLLOWING the enactment by Congress of a law establishing for aviation assistant secretaryships of the War, the Navy and the Commerce Departments, President Coolidge named Edward P. Warner Assistant Secretary of the Navy for Aviation. This appointment was duly confirmed by Congress and Secretary Warner is making at this time a Nation-wide inspection trip in connection with his work.

The elevation of Mr. Warner to this position is peculiarly gratifying to the officers and the members of the Society, on account of his highly valued services in aviation and as an officer of the Society in various capacities.

The appointment has been acclaimed generally with hearty approval, as was natural in view of Mr. Warner's marked ability and his wide experience in aeronautic engineering; not to speak of his very appealing personality and his continuing generosity in cooperative effort.

Mr. Warner became a Member of the Society in 1917 and was elected Second Vice-President representing Aeronautic Engineering in 1923. He has been active in the committee work of the Society, relating to such important phases of the Society's activities as publications, meetings, Sections, research, and standards. At this time he is the chairman of the Aeronautic Division of the Standards Committee. He is also serving his fourth year as chairman of the Publication Committee, in connection with which he has been most helpful in the issuing of the TRANSACTIONS, as well as THE JOURNAL. He is now a member of the Society's Council.

After being graduated from Harvard University with the degree of bachelor of arts in 1916, Mr. Warner attended the Massachusetts Institute of Technology, receiving therefrom the degree of bachelor of science in 1917 and of master of science in 1919. During the World War he was employed as aeronautic engineer for the Air Service in connection with research and also as instructor in the military course of aeronautic engineering at the Massachusetts Institute of Technology. Later he was chief physicist for the National Advisory Committee for Aeronautics, directing aeronautic research work at Langley Field; he was also detailed on work for the committee as technical assistant in Europe. He has made repeated trips abroad to investigate the status of aviation there, with reference particularly to commercial operation. Beginning in 1920, Mr. Warner was a member of the faculty of Massachusetts Institute of Technology, being professor of aeronautic engineering at the time of his appointment as Assistant Secretary of the Navy for Aviation.

Message from Secretary Warner

THE relation between the officers of the Naval Air Service and the Society of Automotive Engineers is of long standing. The Navy has been represented on the Aeronautic Division of the Standards Committee, and the Navy has cooperated through membership on the various subdivisions of the Aeronautical Safety-Code Sectional Committee, of which the Society was one of the sponsors. Many of the officers active in aeronautic work have held membership in the Society during the last 10 years, and they have been liberal contributors of papers and discussions at the Aeronautic Meetings.

It has been natural that there should have been such personal, and in some degree official, relationship with the organization representative of the aeronautic engineer. The technical problems of the Naval Air Service have been specialized in the extreme and have made demand upon the best skill and experience of engineers within the service and without. Only by the use of all available research and experience gained in engineering development, and only by cooperation among all the interested parties, have they been soluble. The Navy has purchased airplanes of many different designs from the aeronautic industry. Whatever the manner of its origin and of its tender to the Government, every standard machine in its ultimate and most satisfactory form expresses the joint knowledge and experience of engineers in the industry and of the Naval personnel, of the results of whose research the private designer naturally avails himself, and whose experience expressed through criticisms of and comments on particular types offers the surest guide to development accommodated to the specialized needs of the service. Through a continuance of such general cooperation of operating personnel and engineers in the service and outside lies the surest road to progress.

Mr. Warner is the author of about 80 published reports and papers, including one on Commercial Aviation in the Eastern Hemisphere, which was presented at the 1921 Annual Meeting of the Society. Among the other papers he has presented at meetings of the Society are: Airplane Performance Formulas, Design of Commercial Airplanes, and Commercial Aviation in 1923.

In 1920 Mr. Warner said with regard to Government assistance of aviation

> There is no European nation which has not clearly seen that airplanes can be kept in readiness for use in war only through the development of their use in commerce and that it is a clear function of Government to assist their use in commerce by every means in its power. The development of an air traffic under the control of its nationals is felt to be more important to many States than is the development of a similarly controlled merchant marine. In addition to the direct military usefulness of the airplanes developed for commercial

work there is motive in the value of air transport as a link between the home country and the dominions or colonies, and an analysis of the measures taken by the various Governments shows that this last incentive is always in mind and it has been the guiding star of such enterprise as the Government-encouraged, although not actually Government-assisted, flights from England to South Africa and from England to Australia in the development of the "Imperial Air Routes" . . . .

In discussing commercial aviation in 1923, Mr. Warner said

> When we attempt to make an examination of the development of the last 22 months, we find that there has been so little change that it affords little scope for comment; the lines laid down in 1920 and 1921 have been followed without material variation, except in a very few respects. If we compare the air-map of the world in 1920 with that of 1923, the most striking difference is to be found in the abandonment of the short routes that were so numerous in the earlier year and their amalgamation into longer international air-lines, each of which covers a much greater distance than any single commercial route laid out 2 years ago.

In a discussion had recently of possible standardization of airplanes and airplane-engine details, not covered so far by the Army and Navy standards, 20 different subjects were listed. In this connection, Mr. Warner as chairman of the Aeronautic Division expressed the opinion that progress could be made in standardizing some of the matters suggested, among these being mountings of fuel gages, starting-motor drives, dimensions of wheels, forms of tail-skid, and dimensions involved in the mounting of instruments.

The Aeronautic Division is scheduled to hold a meeting in Philadelphia on Sept. 1, the day preceding the 1926 Annual Aeronautic Meeting of the Society that will begin there on the following day.

Message from Secretary Warner

Secretary Warner has sent the Society a special message in which the members will be much interested. This is given herewith and is worthy of close study by all concerned. There is every indication that the fine cooperative spirit toward industry that has been maintained in the past by the Navy will continue to be observed.

CARBON DEPOSITION

Two errors occurred in the paper entitled Influence of Temperature, Fuel and Oil on Carbon Deposition which was prepared by S. P. Marley, C. J. Livingstone and W. A. Gruse, for presentation at the Semi-Annual Meeting of the Society, which was held at French Lick Springs, Ind., early in June, as it was printed in the June issue of THE JOURNAL.

The first occurred on p. 609 in connection with Table 3. The figures given in the last line of this table are the total carbon deposit in grams and not the deposit per liter of oil as printed. The pairs of runs made with each of the three fuels indicate how closely the carbon deposits agree in weight when no corrections of any kind were made to the results actually obtained.

The other error occurred on p. 610 in connection with Fig. 4. In this illustration as printed the last two temperature abscissa were indicated as being 480 and 500. No temperature measurements, however, were made between a point slightly below 460 deg. fahr. and 665 deg. fahr. The chart in the corrected form indicating this gap in the sequence of temperature measurements is printed herewith.

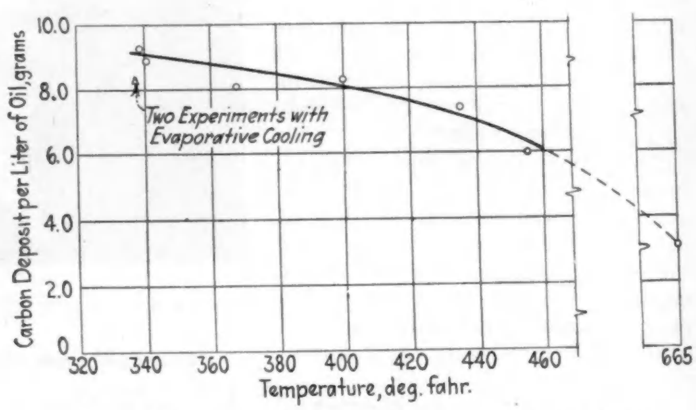

FIG. 4—CURVE OF CARBON VALUES PLOTTED AGAINST HEAD TEMPERATURES

Note Drop in Grams of Deposit per Liter of Oil Consumed as the Cylinder-Head Temperature Was Increased. Two Experiments with Evaporative-Cooling Gave Low Operating-Temperature and Approximately Corresponding Carbon Value, as Indicated by the Triangle

Needed Relations between Service Station and Factory

By A. E. Hutt [1]

Pennsylvania Section Paper

ABSTRACT

IN their own interests the builders of automobiles, who are today giving more value for the car purchasers' money than ever before, should take adequate steps to assure that good service will be rendered by their own and their dealers' service stations. A new automobile owes its ability to perform satisfactorily to cooperation between the engineering and the production departments of the factory. Equally close cooperation of the service station with the factory is necessary to assure continued good car-performance in the hands of the user.

Two advantages to be gained from the proper organization and control of service stations are (*a*) maintenance of the vehicles in first-class mechanical condition at the lowest cost to the owners that is consistent with good work and (*b*) ability of the factory to obtain and tabulate records of the mechanical failures that occur and the adjustments that are needed on the cars it produces.

The time is approaching rapidly when the factories will reserve the right to dictate the methods to be used by service stations in the maintenance of the factories' products and the tools to be used and to insist upon receiving written reports of all repair and adjustment jobs. Such reports will form a valuable reference file for the engineering department.

Information that the factory will gain from such reports will be

(1) How its cars are being treated by owners or their chauffeurs and by the service stations
(2) Approximate cost for vehicle maintenance per car-mile
(3) Cost of maintenance for each unit per car-mile
(4) Units and parts that give the most trouble
(5) Causes of the failures
(6) Effect of climatic conditions upon the vehicles

The service station should make its reports conscientiously and offer suggestions from the management and mechanics for improvement in the vehicles and in repair methods, but no changes in methods should be permitted until they have been sanctioned by the factory. Shop foremen should receive factory training and approval before being given supervision of other men, and it would be better if all service-station mechanics could receive such training.

The factory should provide the service stations with printed instructions for the execution of every job that may be required on its cars and specify the tools to be used. These instructions should preferably be in book form and the mechanics should be urged to read them. In addition, the factory should furnish each service station with

(1) Large lubrication charts of the chassis
(2) Blueprints of the chassis assembly, sub-assemblies and unit parts
(3) Instructions for taking-down and reassembling all assemblies, accompanied by lettered or numbered drawings
(4) Printed forms for reporting all repairs, replacements and adjustments

Mechanics should be required to buy all small tools needed for their work, which should be sold to them at cost. This will ensure uniformity and quality of the tool equipment and proper care of the tools. Definite instructions regarding repair methods result in the mechanics' becoming expert at a particular job by repeatedly doing it in the same way, and this provides a basis for fixed charges for specific jobs. The service station is then enabled to check-up on the men to see whether they are working properly or merely putting in time.

Orderliness and cleanliness are of importance, as they make a favorable impression upon customers and are conducive to the best work. Engines should be cleaned with kerosene before any repairs to them are undertaken. Employes should be forbidden to remove tools or cleaning-rags from customers' cars. Of the greatest importance is the need of the mechanics' knowing the correct valve-clearances, piston and cylinder tolerances and adjustments for the cars on which they work.

The inspecting and tuning-up of new cars, particularly in the lower priced class, before delivery to purchasers, is important and helps to increase new-car sales. The re-conditioning of cars after they have been run a considerable mileage would be a source of revenue during slack periods, would develop a large market for used cars that has not yet been touched and would have a beneficial effect on sales of new cars.

When changing the oil in an engine, the best grade of oil that the market affords should be put in the engine, as lubrication is the foundation of good car-maintenance and the confidence of the customer should be retained. If body repainting jobs are sublet, all necessary steps should be taken to protect the car owner's interests, as he will hold the service station responsible. Failure to do this reflects upon the car builder as well as upon the service station and may result in the loss of customers. The automobile dealers who are selling cars most successfully today are those who are giving the best service.

TODAY it may be stated truly that practically all automobiles are good cars, for never before has greater value been given for the money than the automobile industry is giving at present. The giving of good car value is a great accomplishment but unless adequate steps are taken to assure that equally good service will be rendered by the builder's and the dealers' service stations after a customer has bought his car, the builder will not reap all of the benefit and prestige to which he is entitled and a good car often will acquire a bad reputation in a certain locality because the service station for that territory is indifferent to the interests of the builder or is not capable of giving proper service because its mechanical staff does not understand thoroughly the vehicles it is handling.

An automobile owes its ability to perform satisfactorily to (*a*) the builder's engineering department and (*b*) the quality of the production facilities, machinery and workmen at the factory. The necessity for cooperation between the engineering and production departments of a factory has often been pointed out. It is equally important to secure the close cooperation of the service

[1] M.S.A.E.—President and general manager, Westchester County Bus System, Inc., and Borough Motor Bus Co., New York City.

station. Two distinct advantages to be gained from the proper organization and control of service stations are

(1) Maintenance of the vehicles in first-class mechanical condition at the minimum cost to the owners that is consistent with good work. This will ensure satisfaction of the customers and their continued patronage
(2) Ability of the factory to obtain and tabulate records of the various mechanical failures that occur and adjustments that are needed on all the cars that it produces. This will enable it to ascertain and remedy the weak places in its product and thereby improve its vehicles

Factory Must Exercise Direct Control

I believe that the day is approaching rapidly when all automobile builders will realize that they must exercise some direct control over their service stations and when car agencies will be given only on contractual terms between the factories and the dealers whereby the factories will reserve the right to dictate the methods to be pursued in the maintenance of their vehicles and the tools with which the machine-shop and the service-station mechanics shall be equipped and to insist upon receiving reports of all jobs handled written on forms that are provided by the factory for that purpose. These written reports, when classified and tabulated, will form a valuable reference file for the engineering department, especially when it is considering the desirability of changes and additions to be incorporated in new models.

Quantity production has eliminated the all-round automobile mechanic to a major extent. This necessarily increases the difficulty that is encountered by the service station in obtaining satisfactory workers. This difficulty can be overcome, however, by training men to do a limited number of jobs well and by keeping them for such work. The foreman of the mechanical department should be proficient as regards the whole vehicle, and this man, if no others, should spend some time at the factory to become thoroughly familiar with the construction, assembling and adjusting of the cars, and he should be approved by the factory before taking charge of and supervising others. It would be better if all of the mechanics could have such factory training, but this is not always economically possible.

The factory should also provide printed or written instruction for the execution of every job of which it can conceive and specify the tools to be used for it. Preferably, these instructions should be in book form and every mechanic should have a copy and be urged to read it in his spare time. The book might well be supplied also with each new car, as it would be of great help to owners who may wish to do their own repair-work.

To tell a mechanic what tools he should use to do a certain job may seem foolish, but that such instructions are needed probably will be agreed with by anyone who has had the misfortune to meet in automobile repair-shops the so-called mechanic who apparently has not been long out of school but whose confidence in himself is still more apparent and who does not hesitate to perform any operation on a car with the contents of a discarded soapbox, consisting usually of a pair of pliers, a monkey-wrench, a hammer, and what would be a screw-driver if the man knew how to grind the working end, and all of which commonly are coated with grease and dirt.

Every mechanic should be required to obtain the tools that are needed to do the work that he is paid to do. Preferably the service station should furnish these tools to each mechanic when he is hired; first, because no man should be allowed to start work without the necessary tool-equipment and, second, to ensure uniformity and quality of the tool equipment used in the service station. The mechanic should pay for the tools, as he will then be most likely to take proper care of them. This will not impose any heavy financial burden on the mechanic, as the tools could be sold to him at cost and the amount would not be large in any case. Any expensive necessary tools could be kept in the toolroom and issued to the mechanics on the check system.

Why Instruction in Methods Is Needed

In the absence of definite instructions, when a car is brought to the service station for repairs, no two mechanics will undertake the work in the same way. They may arrive at the same solution as to what is to be done but one will take down more of the car than the other and possibly both will remove more parts than is necessary. This involves wasted labor, which needlessly increases the cost to the customer and creates in his mind the impression that the mechanic does not know his trade.

Any part of a car can be reached probably in various ways but undoubtedly one way is easiest and best; therefore it seems logical that this way only should be used. Moreover, by repeatedly doing the same job in the same way, the mechanic will become increasingly adept and finally expert in that particular work. Such a method provides a basis for fixed prices for specific jobs and the service station can check-up on its mechanics to ascertain whether they are really working or merely putting in time.

Cleanliness Essential to First-Class Work

Cleanliness should be the slogan in all repair-shops. I suggest that all automobile parts be cleaned before any repairs to them are attempted. A mechanic cannot do good work if everything he touches is covered with oil, grease and grime that come off on his hands and get on his tools. If a repair is to be made on the engine, a helper can clean the engine with kerosene in from 15 to 20 min. at a cost of about 40 cents, including the kerosene. This cleaning will have a good psychological effect upon the car owner, who may feel satisfied to pay $10 for a job that he might otherwise think was high at a charge of $2. I do not suggest that repair shops should overcharge for this cleaning; they could do it gratis and would find that it was the best advertising for which they ever paid.

In many service stations very few of the mechanics have all of the necessary wrenches to fit the nuts on a particular car and they borrow those from the tool-kit in the car. Too often they forget to put them back or else replace them so covered with grease and dirt that the next time the owner uses them he soils his hands and perhaps his clothes. The same thing applies to cleaning-rags, which have no intrinsic value but whose absence is most annoying when some small emergency job must be done on the road and all of the cloths so carefully placed in the side pockets of the car are missing. If I conducted a repair-shop I should post a notice reading

> Any Employe Who Opens the Pockets of a Customer's Car, or Removes Anything Therefrom or from Under the Seats, Will Be Discharged.

and I should enforce the rule.

Mechanics Should Know Correct Adjustments

Much more serious, however, are some things that will be mentioned to emphasize the need for more definite

instructions from the factory and of informing the service man regarding what the engineers have done and why they have done them.

In the matter of valve clearance the engineer makes a careful study when designing a cam and his calculation needs to be very accurate. The necessary clearance to allow for expansion of the valve is so intimately related with the design of the entire valve-operating mechanism that it is highly important that the correct clearance be adhered to as closely as possible if the correct valve timing is to be maintained. Yet how many mechanics know exactly what this clearance should be?

"How much clearance are you allowing?" I asked a mechanic who was adjusting the valves in an overhead-valve engine.

"Three-thousandths," he replied.

"For the inlet or the exhaust-valves?"

"Both."

"Is that for a hot or a cold engine?"

"That doesn't make any difference," he answered.

Later I inquired of the shop foreman what clearance he allowed and he said, "Three-thousandths, red hot," but he also gave the inlet and exhaust-valves the same amount. Neither he nor his subordinate was right, according to a check that I made at the factory. Had the foreman been properly instructed as to the correct clearance and informed how incorrect adjustments affect the timing of the engine and the proper functioning of the valves, he probably would have made certain that all engines that came under his care were adjusted correctly and those engines would have functioned as they were designed to function, insofar as the valves were concerned.

At one time I owned a car that gave considerable trouble due to the exhaust-valves sticking in their guides and I asked the chief engineer of the car company to suggest a remedy. His response was that the valves in that make of car did not stick, so the next time I had occasion to go to the service station with this trouble I asked the foreman why it was that my valves were repeatedly sticking whereas other cars of the same make did not have that trouble.

"Is that so?" he replied. "See all those cars in the street?" pointing to a number of cars that were evidently waiting to be brought into the service station. "Well, 90 per cent of them are coming in for the same trouble as yours."

Had reports been sent to the factory of all of those sticking exhaust-valves, the chief engineer would have known the situation and have taken steps to remedy the defect.

How Tuning-Up New and Reconditioning Old Cars Pays

The inspecting and tuning-up of new cars before they are delivered to purchasers is important, particularly of the lower-priced cars that are not given a thorough test after they are assembled and therefore are not likely to reach the public in the best operating condition. This causes a bad first impression that can be avoided easily. I know of one dealer who never delivers a car until he has had it minutely inspected and carefully tuned-up in his own shops. This costs him money that must be deducted from his profit on sales, but the reputation he has built-up for the car and his service in his locality has resulted in largely increased sales.

Complete overhauling or reconditioning of cars after they have been driven a considerable mileage is in large demand. I am sure that the knowledge that this service could be obtained would have a marked effect on the sales of the dealer who rendered it and would also be a source of revenue for the service station in periods that are now slack.

A prejudice exists against having a car overhauled; most owners elect to run their cars almost to death and then trade them in for a new car. This prejudice is due undoubtedly to inability to obtain first-class overhauling. The neglect that arises from lack of this service results in cars being run in a condition that is the reverse of good advertising for the companies that produced them and creates a situation for the dealers who have to accept them in trade that must sometimes be difficult to emerge from without loss. Despite the large number of cars that are operating in this Country today, I believe that a large market for used cars that has not yet been touched could be developed by providing a rebuilding service and guaranteeing the reconditioned cars.

Oil changing is another item of service that should be mentioned. Most owners who send their cars to the service station to have the oil changed do so with full confidence that the most suitable and best quality of oil will be put in the engine. This confidence should be met by providing the finest product that the market affords regardless of the amount of profit that may be made on the sale of the oil. Proper lubrication is the very foundation of good car-maintenance, and the dealer who fails to assure correct lubrication of the cars he handles when he has the opportunity misses the easiest road to satisfied customers and repeat orders.

Maintenance of coachwork as well as of the chassis is demanded by purchasers of automobiles. This consists chiefly of paint and varnish work. Few service stations are equipped to do this work but send the jobs out to shops that specialize in painting. However, if the service station accepts the order for repainting, it should take all necessary steps to protect the property and interests of its patron. The reason that so many repaint jobs are unsatisfactory is that the service stations either sublet them to incompetent and unreliable firms or order the cheapest work that they can get from the paintshop and charge their customers for first-class work. The owner feels rightly that the service station is responsible for the painting, and it is incumbent upon the service station to make certain that the customer will have no reason to complain. Failure to do this reflects not only upon the service station but upon the builder of the car, who may lose a customer.

Information That the Factory Should Supply

The factory is in the best position to know what special tools, jigs and set-ups are needed for servicing its vehicles and should require all service stations for its cars to obtain them and be instructed in their use. The factory should specify the wrenches and other hand-tools that are needed for different units of the vehicle so that the foreman of the repair-shop will know what equipment each mechanic should have for the work he is hired to do. In addition, the factory should supply

(1) Large lubrication charts that show clearly where and what kind of grease and oil are to be used
(2) Blueprints of the chassis assembly and as many blueprints of sub-assemblies and unit parts as are necesary to show thoroughly the construction of the vehicle
(3) Printed instructions for the taking-down and reassembling of all assemblies, accompanied by lettered or numbered drawings or photostat prints with the necessary legends
(4) A large phantom wiring-diagram of the electrical equipment, including battery, ignition, lighting,

and horn, together with instructions for locating and correcting all troubles with the electrical system

(5) Forms for the reporting of all repairs, replacements and adjustments that are made to all of its cars.

Some of the important information that the factory will gain from the reports made on the forms supplied will be

(1) How its cars are being handled by the owners or their chauffeurs and by its own service stations
(2) Approximate cost per car-mile for maintenance of its cars
(3) Cost per car-mile for maintenance of each unit
(4) The units and parts that give most trouble
(5) Causes of the failures
(6) Effect of climatic conditions upon the vehicles, as deduced from the localities in which certain troubles occur, and a fund of other useful information that could not be obtained otherwise except at great expense

The service station should make its reports conscientiously and offer such suggestions for improvements as its experience with the vehicles shall prompt, with particular stress placed upon the subject of accessibility. No mechanic who persistently neglects to perform his work in the way prescribed by the factory should be kept in its employ. Suggestions from employes for improved methods should be welcomed and be forwarded to the factory if deemed meritorious, but no change in method should be permitted until it has been sanctioned by the factory.

Absolute cleanliness and orderliness should be insisted upon. Worn-out or broken parts and other junk should not be allowed to accumulate on the floor or benches. The repair-shop should present an appearance that will create a favorable impression upon customers. Many service stations are excellently operated by men who know their business and who aim to please their customers. The automobile dealers who are selling cars most successfully today are those who are giving the best service.

THE DISCUSSION

A. L. BEALL[2]:—My experience as service engineer for the oil company I represent has been that, in both large and small service stations and irrespective of the knowledge of the car owner and of the shop foreman and the men who do the work, the work is almost always done in the best of faith, but the amount of ignorance, particularly in diagnosis, is appalling. The men do not know what the causes of the troubles are. Whether this is due partly to lack of instruction from the factory or not I do not know, but I want to indorse Mr. Hutt's remarks strongly. Repair jobs are attacked from one point when they should be attacked from another. Sometimes large jobs are attempted when minor adjustment would overcome a noise or a defect that is giving trouble.

I should like to recommend, from my experience of shop requirements, the use of precision instruments for making measurements in the repair of cars. Such instruments are almost invariably lacking in the small shops, and even the large shops, if they have any, are equipped with only cheap ones.

[2] A.S.A.E.—Service engineer in automobile department of the manufacturer's service division, Vacuum Oil Co., Philadelphia.

[3] M.S.A.E.—Chief engineer of the automotive car division, J. G. Brill Co., Philadelphia.

CHAIRMAN C. O. GUERNSEY[3]:—We have asked the members of the Philadelphia Automobile Service Association to be with us tonight and want them to feel free to enter this discussion.

A MEMBER:—I should like to ask Mr. Hutt how many repair jobs he has had on which some washing machine was required for cleaning the car thoroughly before the mechanic began work on it. I am thinking of the lack of inspection or diagnosis. Some of the diagnosticians in the shops are paid wages that, to my mind, would not suggest that the diagnostician could be given credit for having all of the information he should have. Consider the average pay of a mechanic in the shop and the average pay of the diagnostician. Does not that indicate why we have some poor mechanics or poor diagnosticians? How much of this dirt that they have to work in could be removed if we had the right kind of washing apparatus? I do not think the mechanic feels any inspiration to work on a car. Have many shops put in operation any cleaning systems, such as kerosene cleaning-devices, that would make that labor less disagreeable?

A. E. HUTT:—The old-fashioned engine-cleaner that is similar to a little blow-torch and has a hose for attachment to a can of kerosene and another attached to a compressed-air line can be bought for about $2.25. With that the average engine can be cleaned in about 15 min. Even assuming that the shop has no air-compressor, it does not take long, with engines as they are built today, to go over an engine with a brush and some kerosene. The average car owner who has no chauffeur never cleans his engine; sometimes the timer is covered with 1/8 to 1/4 in. of grease and dirt. Imagine a mechanic repairing it and putting it back with all that grime on it. He has to touch some delicate mechanism inside and, if his hands are greasy and dirty, they are not fit to touch it.

While connected with the Fifth Avenue Coach Co. in New York City I started something in my division that never had been done there before. The motorcoaches came into the shop for a general overhauling after each 2000 miles of service. About five coaches had to be overhauled from end to end every morning. Some of the mechanics confined their work to a particular part. Incidentally, we never hired mechanics; we hired floor sweepers and trained them up the line of jobs. These men had to work under the motorcoaches covered with the dirt picked up during 2000 miles. It seemed to me that a man who had to do that work did not have as pleasant a feeling and was not able to do as good work as if the engine were presented to him clean; therefore I directed that the motorcoaches that were assigned for general overhauling each day should be cleaned with kerosene the night before, and the results that we obtained from the men more than paid for the cleaning.

MR. BEALL:—I believe that with proper diagnosis the customer's total bill for repairs always will be smaller than when the diagnosis is careless or improper. I do not hope to see the small country shop have a man with a degree of mechanical engineer and 10-years' training to make the diagnosis, but many shops can afford a high-class man for that work and it will pay the customer, because he has to pay the customary fee 8 times out of 10. Particularly on the basic class of troubles with which I have had experience, the services of a high-priced man for diagnosis would have been cheaper for the customer in the end. Most men in the East who have had long enough experience, factory training and some study can be hired for $40 or $50 per week.

Organize Service Along Production Lines

B. B. Bachman[4]:—There is a possibility of disagreement with regard to the ability to do certain things that Mr. Hutt suggests but there cannot be much disagreement as to the desirability of doing them if a way can be found to do them most efficiently. When he spoke of the need of cooperation by the service department with the engineering and production departments of the factory he should have included the sales department as well. Improper salesmanship is responsible for some of the trouble that has arisen in the motorcoach and truck field. I do not think I need to enlarge upon that.

The explicit factory instructions to which Mr. Hutt referred are very desirable. It is readily understandable, when we review the rapid growth of the industry, that service should have been one of the items, or *the* item, that has lagged behind to a certain extent. The technical engineering development of the automobile was, of course, a prime requisite, because the building of a secure foundation for the industry depended upon the acquiring of technical knowledge. Racing, the observation of performance on the road and a system of trial and error, together with technical training, have developed the technique of automobile design until today it is a reasonably exact although not in any respect a completed science.

When we began to produce automobiles that could be operated with some degree of satisfaction, a demand developed upon which large production is founded. The problems in the service department at which we are looking now have been solved to a large extent in the production department. The building and putting into service in this Country of from 18,000,000 to 20,000,000 automobiles never could have been done if we had had to depend for labor upon skilled mechanics; it would not have been economically possible. Success has been possible simply because men of mechanical training, capable of using highly developed machine-tools and who have ability to learn certain and repeatable operations, have been obtainable.

Much more can be accomplished if the service branch of the business is organized along the lines of the production branch. The small shop in the backwoods or in a small town, that depends for the major part of its revenue upon tourist patronage and has a long slack period between touring seasons, will have difficulty in maintaining an efficient organization, but we have large centers of population in which thousands of cars are operated and where the general character of service is no better. I think the responsibility for it is not isolated in the service department and does not lie entirely at the factory; it is divided between the two. More explicit directions can be given by the factories to their service stations but it is very difficult to give explicit instructions for finding troubles. The correct diagnosis of trouble develops only from experience. We all have had the experience of looking through an instruction book for a new piece of machinery and failing to find mention of and the cure for the particular trouble with it that confronted us. Usually we have been able to find the cause of the trouble because previous experience enabled us to eliminate the things that were unlikely and concentrate on those that were probable.

Not every man, even with instructions, can diagnose; some excellent mechanics have not the imagination that enables them to see the relationship of parts and the combination of conditions that may produce certain results. Good diagnosis is the outgrowth of the experience of the service organization, although undoubtedly it can be helped by factory training that thoroughly familiarizes the men with the complete structure of the car; but the probabilities are that a man has little opportunity at the factory to observe troubles of the character of those that will confront him in the service station.

In the matter of explicit instructions for repair operations, time studies in repair work and the analysis of costs, I believe it is generally true that the service branch of the automotive business has not even made a start. I believe it will help to assure a better quality of work and will result in lower cost, except in a few cases, if we analyze the cost of operations; that is, analyze in a comparative way the time required and the methods used in the operations, as the factory analyzes the production of a part and tickets it for its course through the production-line. Scores of automobile-repair operations of a routine nature can be standardized in that way.

As an engineer I can see the value of making reports on repair jobs. However, that seems to me likely to lead to a cumbersome mass of detail, particularly with some passenger cars that are in large production, and would increase overhead costs in repair shops to a burdensome extent if these reports are to be made out in an intelligent way and forwarded.

Nothing that Mr. Hutt has said in his paper is of more importance with regard to the efficiency and quality of repair work than to have a car clean before work is started on it. Any reasonable cost that is entailed in cleaning the car to obtain that result is justified.

Time Saved by the Rebuilt-Unit System

Chairman Guernsey:—Mr. Bachman's company pursues in its service stations the system of unit repair and unit replacement of parts as a basis of overhaul on jobs in service. Will he or someone from his organization tell us about that?

Richard M. Brown[5]:—For the last 8 or 10 years the Autocar service stations have had in operation the rebuilt-unit system, particularly in connection with the two-cylinder models. As we found it was necessary sometimes to please our customers by giving them an overhaul job within 3 or 4 days, we carry a stock of rebuilt service-units, such as engines, transmissions, rears, brake assemblies, and so on. I remember when it took us 3 or 4 weeks to complete an overhaul job, and then it was not the best; now we can practically overhaul a two-cylinder truck by the rebuilt-unit system in 4 or 5 days and can do a painting job in a few more days. I fear, however, that the time is coming when our customers will want us to do that in 24 hr.

We take care of about 40 truck jobs per day, besides making unit overhauls and that sort of thing. We have a very low labor turnover; most of our service-station men have been with us from 3 to 15 years. We employ four or five engine builders who are specialists in that work, and we also have men who work on transmissions, rears and other units exclusively. In our magneto room we have expert electricians who work on magnetos and generators. All of these men have been with us 8 or 10 years. All of the unit-repair men are specialists and constitute a separate department of the shop. The men in the repair-shop proper perform the minor operations, remove and install units and take down and reassemble the trucks.

Our repair service has received excellent cooperation from the engineering department, which sends us bulletins that tell how to do things. The service stations are

[4] M.S.A.E.—Engineer, Autocar Co., Ardmore, Pa.
[5] Service department, Autocar Co., Philadelphia.

well equipped with precision tools and instruments, such as cylinder-bore gages and micrometers, and we have all sorts and sizes of reamers, drills, vertical drilling-machines, and equipment of that sort.

We have found that very few men know anything about diagnosing trouble. Our service department has dozens of employes who cannot diagnose trouble; I believe that a man must be born with the instinct for it. I dare say that we have half a dozen men at our branch in Philadelphia who are expert trouble-finders. They are especially good at locating noise. We have purchased several instruments of the stethoscope type in the last few years for use in locating knocks in engines. I can take such a device and hear noises all over the engine and would come to the conclusion that the engine should be entirely rebuilt. Then one of our trouble-finders will take it and say, for example, "That is No. 1 bearing," and generally he is right. Such men become proficient only after long experience.

I agree with Mr. Hutt that cleanliness in the shop is essential. We try to keep our shops as clean as possible. We clean the engines, transmissions and parts before work on them is started; but some of the trucks, for instance, those used in the ice-cream business, in coal dealers' work, dump trucks, and those used for hauling fertilizer and such materials, are a sight to behold. We have to steam-clean some of the latter to get rid of maggots and at times have had to carry men from under some of the cars to revive them. When we get a vehicle like that and do the necessary work on it, the customer frequently feels that he is overcharged, as he does not realize that the offensive condition of the truck causes the labor charges to run up. Fortunately, we sometimes receive a car in good clean condition from a florist or a jewelry firm, which is very different.

Traveling Instructor from Factory Would Pay

R. W. A. Brewer[6]:—I think it would be a good policy for the factories to send a supervisor or instructor to the service stations to spend perhaps a day or two at each to observe the work that is being done and give hints to the foremen and mechanics as to the best ways to do various jobs. That would bring much better results, and bring them more quickly and forcibly, than any number of charts. To send out service bulletins is well, but the personal contact of the man from the factory who can go to the men who are taking down the cars and say, "This is the way we do it at the factory and I think you will find it the best way," is very helpful. That would not be very expensive to the factory and the expense would be repaid many times in better service, which is absolutely necessary nowadays if a company is to build-up and maintain really efficient factory representation in a locality.

As regards the complete overhauling of used cars, I think the psychology of the American public is rather toward discarding the vehicle than spending money on it and using it another year. As a rule, the only reason a man uses the car another year is that at the end of the first year he cannot get much for it and at the end of the second year can get practically nothing; then he is not inclined to spend money for overhauling and the purchase of a set of new tires and other replacements to get a little more usage out of the car when he can buy a new one for a small price.

Mr. Hutt:—How about the other American who buys that car in poor condition? Somebody buys the used car; many of them are on the streets. Why not have them in good condition? A man often will keep a car for some other reason than that he cannot buy a new one. I know a certain make of car that in 1923 was very distinctive and had lines that the car never had before and never has had since. That particular car, which is in the hands of owners of somewhat artistic taste, would be preferable to the new model if it could be well rebuilt.

Mr. Brewer:—Often a man is mechanically inclined and derives much pleasure and information from rebuilding a used car. I think the man who buys a second-hand car, as a rule, buys it first because he has not the money to buy a new one and, secondly, because he likes to work on it and make it worth more than he paid for it.

Buyers Misled Regarding Car Care

F. L. Berger[7]:—Mr. Hutt touched very briefly on the difficulty of the service man in selling service. If all cars are good cars today, and I believe they are, a staggering volume of service work is being done on these good cars that, from the service man's point of view, probably could be avoided if the owners would give the cars proper attention. Millions of people own automobiles who do not know the first thing about them. They rely upon what a salesman has told them, and the higher the price of the car the less they think should go wrong with it, which probably is true. Our experience is that certain salesmen cause us more trouble than others. Whether a car costs $15,000 or $500, both would need to have carbon cleaned out of the engine, but the tendency is for the salesman to create the idea that, because a man pays more for a product, that work is unnecessary or will not become necessary until such a far-away date that he will forget the sales talk. Then when the man does bring this masterpiece of engineering into our service station and is presented with a bill of $40 or $50 for cleaning out carbon and grinding-in valves, he is likely to feel injured and the service station is blamed for creating another dissatisfied customer.

If factory executives and dealers could make the salesmen see the importance of pointing out to a customer that the higher the class of a piece of machinery which he buys, the more careful upkeep it requires, and that if the purchaser is not willing to provide the care himself he will have to pay someone else for it, I think that much misunderstanding would be avoided.

Walker Gilmer[8]:—I do not believe that the average mechanic would learn much of value from seeing cars assembled in the factory, and I doubt if the mechanics in the average factory know much about servicing a car; but the supervisor or foreman of a service station would acquire useful information.

How Sweepers Are Trained as Mechanics

R. E. Plimpton[9]:—Mr. Hutt referred to turning floor sweepers into mechanics. I would like to know if he hires these men as sweepers and if they are the kind that one would expect them to be. Does he have a school for them or pick unusual men and pay them the price for the time they are kept at sweeping?

Mr. Hutt:—That system was borrowed, I believe, from the General Omnibus Co. of London and goes to prove the possibility of training men to do well some

(*Concluded on p. 182*)

[6] M.S.A.E.—Consulting engineer, Ridley Park, Pa.

[7] M.S.A.E.—Assistant to the chief engineer of the automotive car division, J. G. Brill Co., Philadelphia.

[8] M.S.A.E.—Chief of engineering, L. H. Gilmer Co., Tacony, Philadelphia.

[9] M.S.A.E.—Associate editor, *Bus Transportation*, New York City.

The Heating and Ventilating of Motorcoaches

By L. C. Josephs, Jr.[1]

Annual Meeting Paper *Illustrated with* Drawings

ABSTRACT

As heating is accomplished principally by convection, which means movement of air, it is therefore related to ventilation and the two subjects must be considered together. Their connection is further illustrated by the fact that, if the heating is insufficient, the ventilation is frequently cut off with a view to raising the temperature and, if the ventilation is poor, the windows will probably be opened, which will destroy the effect of the heating-system.

A ventilating system is required on all vehicles and a heating-system is needed at certain times in practically all parts of the Country.

Both systems should perform their functions efficiently in an entirely unobtrusive manner. To supply heat and air and then exhaust the air is a simple problem but to control the proper amounts of heat and air requires careful engineering, especially when the variations of passenger load, climate and outside temperature are taken into consideration.

Assuming that 350 cu. ft. of air is required per hr. per passenger, the volume of air needed in a 29-passenger single-deck motorcoach will vary from 10,500 cu. ft. per hr., for a normal full-load, to 15,750 cu. ft. per hr., when a standing load of 20 or 25 persons is added to the normal load.

Methods of taking advantage of natural forces, such as the slight vacuum inside the coach and the pressure outside produced by the motion of the vehicle, for operating the ventilating-system are described. Other means include suction ventilators, the taking of air for supplying the carbureter from inside the coach body, and the utilizing of the flow of air produced by a cooling-fan.

The requirements of the heating system include unobtrusiveness, protection of passengers from hot pipes and danger from fire, even distribution, and freedom from noise and fumes.

Of the total amount of heat required, about 70 per cent is needed to overcome radiation losses through the roof, floor, sides, and glass of the coach body; the remainder, to heat the air used in the ventilating-system. In terms of British thermal units per hour per seat, a rough estimate places the allowance at 32 B.t.u. per deg. fahr. of temperature difference between the inside and the outside of the coach. An adult at rest is said to supply 400 B.t.u. per hr., which means that the passengers would supply all the heat needed for a 12.5-deg. fahr. difference of temperature. The total amount required varies with the type of service and may reach 56,000 B.t.u. per hr., as compared with 150,000 to 300,000 for steam-railroad coaches.

Among the sources and methods of heating are mentioned separate heaters, either oil-burning or coal-fired, and the losses from the gasoline engine, including those from the cooling-water and the exhaust. Of these the heat obtained from the exhaust is in most common use. Air from the cooling-fan, as used on passenger cars, is sometimes adapted to motorcoaches but does not meet all the requirements. When exhaust gases are used, seamless tubing is recommended as supplying the best type of radiation. The most effective heating is obtained by admitting the heat near the floor at the outside of the body and allowing the natural convection to carry it past the windows toward the roof and the cold air to descend in the center of the body.

The two subjects, heating and ventilating, must necessarily be considered together in a motorcoach. The designs and equipment in use today are not very different from those of earlier times; and tests made on present-day vehicles demonstrate that heating and ventilating standards are not so good as they should be or can be made. In any vehicle, heating is accomplished principally by convection, which means movement of air, and is therefore intimately related to ventilation. This close connection is illustrated in several ways. If a coach has a good ventilating-system but a poor heating-system, attempts will be made in cold weather to shut off the ventilating-system to raise the temperature inside the vehicle. Immediately complaints will be made of gas fumes, headache and other signs of poor ventilation. On the other hand, if a coach has a good heating-system but poor ventilation-equipment complaints will arise immediately that the inside of the coach is filled with foul odors, passengers will begin to open windows and probably will destroy completely the very best heating-system.

TABLE 1—LOWEST AND AVERAGE TEMPERATURES IN VARIOUS PARTS OF THE COUNTRY DURING THE 8 MONTHS IN WHICH HEATING IS REQUIRED

Locality	Temperatures, Deg. Fahr. Lowest	Average
Portland, Me.	—17	33
New York City	— 6	40
Virginia	— 5	45
Detroit	—24	35
Chicago	—23	36
Memphis	— 9	50
Atlanta	— 8	51
New Orleans	7	60
Fort Worth	— 8	49
Spokane	—30	37

A ventilating-system is required on every vehicle, whether it is operating in a northern or a southern climate; a heating-system is required in the greater part of the United States. Table 1 gives the lowest and average temperatures in various parts of the Country during the eight months in which heating is required. It is apparent that very few parts of the Country will not appreciate a heating-system at certain times.

Fundamental Requirements

The fundamental requirements of both the heating and the ventilating-systems for motorcoaches are like the fundamental requirements of many other elements of

[1] M.S.A.E.—Engineer, International Motor Co., Allentown, Pa.

a vehicle, namely: they must maintain a certain standard of efficiency in an entirely unobtrusive manner. An average passenger on a motorcoach ordinarily should not be aware that either a heating or a ventilating-system is in use, except for the fact that he has a pleasurable sensation in riding in the vehicle. The real problem of a heating and ventilating-system is not complicated and comprises a box to which some heat must be supplied, some air brought in, and other air taken out. The question of the quantities of heat and air to be handled and the methods of controlling the flow of heat and air call for careful engineering.

The general subject of coach heating is not different from that of heating in other places. The general laws of radiation, conduction and convection of heat are applicable to a motorcoach, provided the necessary constants to be used in the formulas are known. A study of insulation and its relation to heating, the area and volume of the part to be heated, window leakage, and the like bring up the same problems in a motoroach as in a railroad car.

Twenty-nine-Passenger Single-Deck Motorcoach

In ventilation the same general principles also apply to both. A certain volume of air should be provided per passenger, with the necessary means for bringing in fresh air and exhausting the used air. In this discussion, a study will be made of a 29-passenger single-deck motorcoach, as this is the type of vehicle in most common use in many places. The motorcoach body, a box 7 ft. 6 in. wide, 6 ft. 3 in. high, and 22 ft. long, has a superficial area of about 684 sq. ft., of which 100 sq. ft., or 14.6 per cent, is glass. The volume is about 1000 cu. ft. This box is mounted on a chassis that travels at speeds as high as 50 m.p.h., which serve as excellent means of operating the ventilating-system. The powerplant is an excellent source of heat for supplying the heating-system, inasmuch as 4 or 5 gal. of gasoline is burned per hour at a thermal efficiency of not more than 25 per cent. Part of this 75-per cent thermal-loss is available for operating the heating-system.

The ventilating-system applied to a coach must be entirely unobtrusive. Parts attached to the outside of the body must fit into the general lines without spoiling the appearance; and this is even more true of the inside. No air-currents caused by the ventilating-system should be perceptible as either hot or cold drafts and, of course, no leaks should be present.

In some cities, ordinances cover the amount of ventilation of public vehicles. The City of Chicago requires 350 cu. ft. per hr. per passenger for the cars of the surface lines. This is as high as the requirement of any other local ordinance. From the standpoint of good ventilating-engineering practice, however, the value is very low. In many places the building laws require from 1500 to 1800 cu. ft. per hr. per person for assembly halls and public gathering-places; and for schools and hospitals the requirements are as high as 3000 to 6000 cu. ft. per hr. per person.

Allowance for Standing Load

To secure 350 cu. ft. per hr. per person, however, is a real problem. This amount is not impossible for a 29-passenger single-deck motorcoach carrying just 29 passengers and the operator, for, under these circumstances, the total ventilation would be 10,500 cu. ft. per hr. which is about that of the best motorcoach practice of today. But when a standing load of 20 or 25 persons is added to the normal load in such a coach, it is difficult to provide each of these passengers with 350 cu. ft. of air per hr. This would amount to 15,750 cu. ft. per hr Ventilating requirements should not be changed greatly by climate or outside temperature. In other words, the above requirements should give sufficient ventilation in winter or summer in any part of the United States. In the summer, to make the coach cooler, additional ventilation can easily be obtained by opening the windows.

Ventilation calls for a certain rate of change of air inside the coach body. This means metering the airflow either into or out of the body and some method of producing a flow of air. Certain natural forces acting on the body have the effect of producing a flow of air. It has been found from experiment that a coach without ventilating equipment tends to develop a slight vacuum inside the coach at the front end, and a slight pressure at the rear end due to the motion of the vehicle. The vehicle itself, when traveling at high speed, develops a pressure or bow wave outside the coach at the front end and a slight vacuum or suction at the rear. Use can be made of these phenomena in operating a ventilating-system. Ventilation can also be secured by the use of suction-type ventilators similar to those commonly used on railroad coaches, in which suction is produced by the flow of air along the outer skin of the vehicle. Another source of ventilation is the taking of air for supplying the carbureter from inside the coach body. In a modern motorcoach traveling at 30 m.p.h., this will amount to from 900 to 1200 cu. ft. per hr. A fourth source of ventilation available is the airflow produced by a cooling fan, as is the common practice with certain types of passenger-car heater.

Suction Ventilators Not Sufficient

In supplying ventilation to the coach, it is important that the necessary forces shall be provided to insure a flow of air through the system. Merely placing suction ventilators on a coach, on the theory that these ventilators will suck a certain amount of air out and that the inflow of air will be taken care of somehow, is not sufficient. The system in most common use at present consists in putting suction ventilators on the roof and depending on window leakage and air from the doors, when open, to supply the intake. This is not adequate. Four ventilators of the best makes when mounted on the roof of a coach traveling at 20 m.p.h. will exhaust about 7200 cu. ft. per hr., provided no restriction in the intake exists; but if the doors and windows are kept closed and are reasonably tight, the amount of air exhausted by the ventilators is very small. At a speed of 20 m.p.h., even with loose-fitting windows, an infiltration of more than 2700 cu. ft. of air per hr. cannot be counted on and additional means for getting air into the coach must be provided. This can be done either by a cowl ventilator or similar means at the front end of the body, or by using one of the types of heater in which air is taken from the cooling-fan inside the engine hood and forced into the body of the coach.

It having been shown that four ventilators of the best type will not supply sufficient exhaust even under the best conditions, additional suction can be secured in the body by drawing the carbureter air from the inside. When traveling at an average speed of about 20 m.p.h., this combination will exhaust from 6000 to 9000 cu. ft. per hr. We see, therefore, that almost all the available means for supplying air to the body and exhausting it must be used, if adequate ventilation is to be secured.

Balancing Supply and Exhaust

The problem of balancing the amounts of air supplied and exhausted by these various means and of providing a simple control-system is also very important. The control of the ventilating-system should be only partial. The differences of pressure available for operating the system are very small and difficult to measure, and it must not be possible for the operator to cut-off all ventilation from the coach. The control must be sufficient only to take care of the differences of pressure caused by differences of schedule, as, for example, the cases in which the doors are seldom opened, or the weather conditions and the velocity of the outside air vary.

Leakage around the doors and the windows is an unknown quantity and subject to change as the coach body becomes old and the fit of various parts becomes imperfect. On new bodies, the infiltration losses around the windows may be only 5 per cent of the ventilation requirement, but after several years of service these losses may amount to 25 per cent. In northern climates, double windows may be desirable, to prevent both heat radiation and local drafts.

Most ventilators of the suction type now on the market are inadequate, a great variation existing between different makes. The best are designed on aerodynamic principles; the poorest are about as effective as a hole in the roof. Most of them, however, are inadequate because an attempt has been made to do too much in too small a space. Some also are defective in that they leak in the rain.

Drafts

Care must be taken to prevent drafts; but this is not easy, for, in the case cited, about 15,750 cu. ft. of air per hr. is required in a body the volume of which is only 1000 cu. ft. This means 16 changes of air per hour. Flow-rates of more than 2 or 3 ft. per sec. produce noticeable drafts; but these flow-rates may be slightly higher for warm than for cold air.

A common illusion that might be mentioned in connection with drafts is the mistaking of radiation loss for a draft. It is common, when sitting in a railroad coach in cold weather, to feel an apparent draft from the window, whereas the movement of air at the window is so slight as to be impossible of measurement. The sensation arises from a direct radiation-loss from the passenger's body through the window that produces a feeling of intense cold on the side toward the window. The only cure for this condition is double windows.

The requirements of heating also call for unobtrusiveness. No parts should project into the coach to annoy passengers, and no hot pipes should be present with which a passenger can come into contact or from which may arise a risk of fire. The distribution of heat must be such that a passenger will not have the sensation of being hot at one portion and cold at another portion of his body.

Noise and fumes, of course, are objectionable.

The amount of heat required is not always easily determined and depends upon the difference in temperature between the inside and the outside of the vehicle. A certain amount of heat, roughly about 70 per cent, in the case of a 29-passenger single-deck motorcoach, is required to take care of the actual radiation losses through the roof, floor, sides, and glass of the coach body. The remainder is required to heat the air used in the ventilating-system, that is, not only the air actually handled in the system but also the amount that leaks in around the window-sashes and through cracks, and to replace the air lost on account of the opening and closing of the doors during stops.

Heating Requirement per Seat

The requirement in British thermal units per hour per seat cannot be given exactly, for these are dependent largely on the design of the vehicle. Roughly, it may be estimated that, in a single-deck 29-passenger motorcoach, an allowance of 32 B.t.u. per hr. per seat per deg. fahr. of temperature difference between the inside and outside will take care of the heating and ventilating losses. This amount of heat is dependent on the capacity of the vehicle and not on the actual number of passengers on board. It must be supplied in any case. The ventilation, of course, need be supplied only when the passengers are actually on board. An adult at rest gives off a total of 400 B.t.u. per hr., which means that the passengers supply all the heat needed for a 12.5-deg. fahr. difference of temperature.

The amount of heat to be provided is also dependent on the service given. In city service, passengers do not expect a temperature above 50 deg. fahr. and are therefore satisfied to retain their outer clothing but, on long rides in a parlor coach, they expect to remove their overcoats and desire a much higher inside temperature, say 65 deg. fahr. In long-distance riding, however, the doors are opened less frequently and the heating and ventilating-systems can be designed with fewer unknown factors.

Assuming 32 B.t.u. per hr. per seat per degree difference of temperature, the total number of British thermal units per hour required in a motorcoach under fairly severe conditions might reach 56,000. This may be compared with steam-railroad figures, which range from 150,000 to 300,000 B.t.u. per hr. A steam-railroad coach approximates a box 10 ft. wide, 9 ft. high. and 62 ft. long, omitting the vestibules, and has a superficial area of 3840 sq. ft., of which about 310 sq. ft. or 8 per cent is glass. Its volume is about 5570 cu. ft. The difference between the heat required for a motorcoach and for a railroad coach per unit of size is principally due to the heavy construction and insulation used in the railroad coach, which reduce the heat losses in spite of the fact that the service is more severe.

With the exception of those in Florida and possibly Southern California, every motorcoach should be supplied with a heating-system. As the type of system can be made subject to regulation, no reason exists why the same system cannot be applied to all coaches in all parts of the Country, with the possible exception that double windows might be provided in some of the more northerly climates.

Sources and Methods of Obtaining Heat

As regards the sources and methods of heating, heat can be obtained from a separate heater, either oil-burning or coal-fired, similar to those used on trolley-cars; but these are distinctly objectionable from the standpoints of cost, weight, valuable seating-space occupied, cost of fuel, and the necessity for frequent attention, and are not used to a great extent. The best system for heating a coach is naturally one that utilizes the losses from the gasoline engine. These are of two kinds, those from the cooling-water and those from the exhaust. The amount of heat contained in either the cooling-water or the exhaust is ample for heating the coach.

For several reasons, the heat from the cooling-water is not generally used for this purpose. Considerable weight would be added to the system because of the necessary piping for low-temperature radiation and be-

cause of the weight of the additional water in the system. The space that would be occupied by such piping is large, and some difficulty would be experienced in keeping the piping tight and in providing against freezing in winter. Moreover, regardless of whether the heating-system is connected in series or in parallel with the engine cooling-system, interference is caused with the proper operating-temperature of the engine. In steam-cooling systems some possibility exists for heating in this manner but even such a system is open to some of the same objections.

Exhaust Heating

The system of heating commonly used utilizes the heat obtained from the exhaust. Plenty of heat-units are contained in the exhaust but they are not all available. Although the temperature of the exhaust is approximately 1000 or 1100 deg. fahr., a large part of the heat is lost by radiation from the exhaust-manifold and from other piping before it can be conducted into the body. The risk of fire would also make it undesirable to bring so high a temperature supply directly into the body. As a matter of fact, only a small portion of the heat in the exhaust can be used for heating but, if it is carefully conserved, it will be sufficient to meet a large part of the requirements. Because of the high temperature of the exhaust gases, not a large amount of radiation is needed, and protection must be provided against contact with passengers as well as against possible fire-risk, if the pipes pass through wood or other inflammable material. Care must also be taken to keep the system tight so that no fumes will enter the body of the coach, and to deaden the drumming or vibration of the heater pipes caused by the pulsations of the exhaust.

Air from the Cooling-Fan

A method of heating used on passenger automobiles can to some extent be adapted to coaches, that is, air from the cooling-fan that has been heated by passing through the radiator can be carried back to the body. This system is desirable from the standpoint of moderate heat as well as of supplying an additional means of ventilation. Objections to this system, however, are that oil vapor from the engine may be blown into the body and that considerable noise may be carried in through the air-duct. But this system alone will not meet the heating requirements, and the heat supply may be increased by air from the exhaust-manifold or by a separate heater in the exhaust-line. This will materially increase the amount of heat supplied but will probably not furnish enough heat continually to meet the requirements; and additional heat must be furnished.

For a heating-system using exhaust gases within the body, seamless tubing offers the best type of radiation, because its weight for large unit-surfaces is very low and because it can be welded and bent conveniently to form the various connections. This tubing has a radiation factor of 2 B.t.u. per sq. ft. per hr. per deg. fahr. of temperature difference between the gases inside and the air in the body. It is difficult to get sufficient radiation surface to supply the total heating requirements and, for this reason, it is probably desirable for a heating-system, as well as a ventilating-system, to use more than one means of heat-supply. In other words, an adequate heating-system probably will require radiation pipes within the body, to supply heat from the exhaust gases, and means for blowing in hot air from the fan through a supplementary heater, located either over the exhaust-manifold or at some other point in the exhaust-line.

Method of Supplying Heat

The proper method of heating, of course, is to supply the heat near the floor at the outside of the body, and to allow the natural convection to carry this heat past the windows toward the roof and the cold air to come down in the center of the body. The actual currents of air-flow as produced by the heating-system are much disturbed by a high rate of ventilation. The control of the system should be complete from no heat to the full amount. This control must be easy of manipulation by the hand of the operator, so that it can be varied from time to time during the run. As the heating-system is directly connected with the losses from the engine, the amount of heat supplied will depend on the load on the engine and will require regulation frequently under differing running-conditions. Great care must be taken to provide against any gases or smell within the coach body. This means not only tight joints, but a muffler provided with a trailer pipe to carry the gases to the rear, and some sort of diffuser to mix the gases with the fresh air as they are discharged. It is important also to have the minimum of back pressure at the engine; in some cases, a high back-pressure will cut-down the power-output and cause burning of the exhaust-valves.

It is doubtful whether any coach is now equipped with an adequate heating and ventilating-system, but no reason exists that a simple system for heating and ventilating cannot be designed for every type of coach body in use in any part of the Country. In general, the requirements are that the system must supply not less than 350 cu. ft. of fresh air per hr. per passenger and that the heating-system should be sufficient, with the full amount of ventilation, to maintain a temperature of at least 60 deg. fahr. within the body when the outside temperature is zero.

THE DISCUSSION

W. J. Mayer[2]:—I had occasion recently to experiment with five ventilators that are at present on the market to see whether they really check with what was claimed for them as to efficiency. I constructed a box approximately 4 ft. wide, 4 ft. high and 4 ft. long. In the center of the top and on one side, I cut 6-in. holes. These holes were the only openings in the box, all joints being sealed. Taking each of the five ventilators, one at a time, I placed them over the hole on the top of the box

[2] Assistant engineer, Edward G. Budd Mfg. Co., Philadelphia.

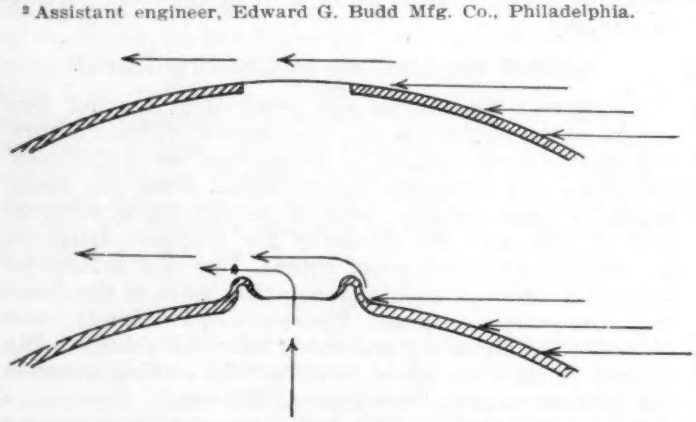

Fig. 1—Method of Placing Humps across the Front and Back of Ventilator Openings

The Blast of Air Striking the Hump in Front of the Ventilator Opening in the Lower Sketch Bounded Up, Creating a Slight Vacuum in the Top of the Ventilator and Increasing the Capacity of the Ventilator 35 Per Cent

and inserted an anemometer in the other hole. A blast of compressed air equivalent to a velocity of 25 m.p.h. was then directed across the ventilator. It was surprising to see that only one of the five ventilators actually lifted the air from the box sufficiently to cause the anemometer to operate. By increasing the velocity of air to approximately 35 m.p.h., little difference, if any, was noted. This seemed to indicate that, unless there is a positive pressure from leaks around the windows or other places in the vehicle, for the air to enter and cause a positive pressure inside, these ventilators would be inoperative.

I placed 3/8-in. humps entirely across the front and back of the openings of one well-known make of ventilator, as shown in Fig. 1. Immediately, the ventilator became operative, lifted the air in the box and caused the anemometer to register. The blast of air striking the hump in front of the ventilator opening bounded upward, creating a slight vacuum in the top of the ventilator. Naturally, this pulled the air from the box. A windbreak at the top of a chimney, as shown in Fig. 2, works on very much the same principle.

With one exception, the other ventilators could be

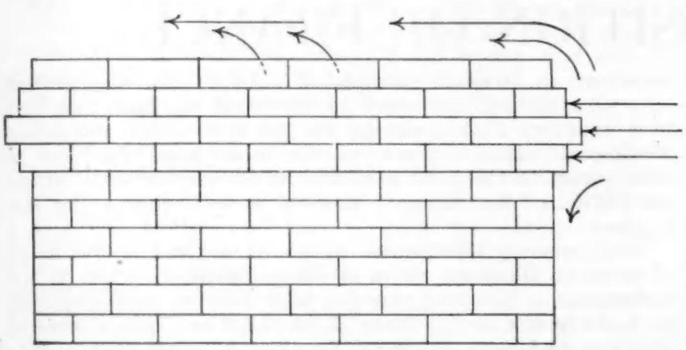

Fig. 2—Construction of Windbreak at Top of Chimney
By This Method, Down Drafts Are Prevented and the Upward Draft Is Improved

made to operate by following the same method of placing a hump in front of the openings. The exceptional ventilator mentioned could not be made to operate under any condition. A familiar type of ventilator used on street-railway cars which has proved very efficient is shown in Fig. 3.

J. W. Saffold[3]:—How efficient was the most efficient ventilator?

Mr. Mayer:—With a wind velocity of 25 m.p.h., the anemometer registered 28 ft. per min., or 14.3 cu. ft. per min. actual lift, on the most efficient ventilator.

Mr. Saffold:—Is 28 ft. per min. enough?

Mr. Mayer:—Comparing the ventilator last alluded to with the others tested, it is by far the most efficient. It must be remembered that in actual use the volume of air passing through these ventilators is increased considerably by pressure built-up inside the body, due to air leaks around windows and other means of ingress. When an air-pressure is built-up inside the body, the question of capacity dwindles down to the resistance that the ventilator offers to the exhaust of the air.

Mr. Saffold:—Is anything on the market adequate?

Mr. Mayer:—I am not prepared to answer that at this time.

E. W. Pughe[4]:—Has anything been accomplished in carrying the exhaust up toward the roof and utilizing

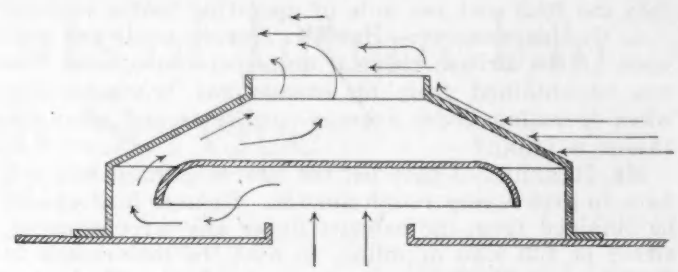

Fig. 3—Familiar Type of Ventilator Used on Street Railway-Cars
This Design Is Based on Sound Principles and Has Proved Very Efficient

ejector action to overcome the unpleasant effect of exhaust gas sucking in at the rear end, particularly on double-decked motorcoaches?

L. C. Josephs, Jr.:—Exhaust gases create a real problem that I do not think anyone has solved as yet. Bringing them out at the side of the wheels is a fine arrangement when the motorcoach is running, but, if the vehicle is standing still and the windows are open and if there is a little excess oil in the fuel, the fumes and smoke will drift up the side of the motorcoach and into the windows. It is also true that, when the motorcoach is in motion, a suction is produced at the rear and, if the rear windows are open, the fumes and smoke may be sucked in.

Our experience has been that the best method is to dilute the gas as soon as it comes out; then, if it is sucked in, it will not be so objectionable.

A Member:—It has been suggested that the end of the exhaust pipe be connected with some form of ventilator that will diffuse the air so that it would be drawn into the outer ventilating-chamber. Those who experiment with carbureters know the type of exhaust pipe that could be shaped into the form of a nozzle and could be used similarly to the smoke stack of a locomotive to start a movement of the lower strata of air.

Mr. Josephs:—That method has been the subject of experiment but no definite solution has been reached. One of the limitations to be considered in working out the problem is the matter of size. It is true that the energy contained in the exhaust gases at their temperature and velocity is sufficient to move as much as 3500 or 4000 cu. ft. per min. The right size of venturi must be used. It could be used if anyone had the room in which to install it.

Pierre Schon[5]:—In the last 2 years I have had considerable experience in motorcoach operation. We had a fleet of 100 pieces of motor equipment, both motorcoaches and trucks, which covered an average of 7500 miles per day, or more than 4,000,000 miles in the 2 years, operating principally over gravel roads. A very accurate cost system on operation and maintenance gave us the cost per mile and, having 14 different makes of motorcoach and truck in service, an analysis of the cost per mile of each vehicle at the end of each month disclosed some very interesting figures.

In figuring the operating cost per mile, however, of motorcoaches of various sizes and seating capacities, from 7 to 24-passenger, we found that an established standard of $0.01 per seat per mile came very close to the actual cost of the 16 to 20-passenger motorcoaches as a basis. As the capacity decreased to 12 and 7-passenger vehicles, the cost was greater than $0.01 per seat per mile, but when the capacity increased above 20 passengers, we found that the cost was less than $0.01 per seat per mile. Make of vehicle, operating conditions and maintenance facilities are important factors entering

[3] A.S.A.E.—President and sales manager, Devices Development Co., Cleveland.

[4] Engineer, Chevrolet Motor Co., Detroit.

[5] A.S.A.E.—Sales engineer, General Motors Truck Co., Detroit.

into the final cost per mile of operating motor vehicles.

A. G. HERRESHOFF[6]:—Has Mr. Josephs made any estimate of the British thermal units per horsepower that can be obtained from an exhaust-gas heating-system when operating under average conditions and when the engine is idling?

MR. JOSEPHS:—I have not the figures with me and will have to give a very rough answer. Enough heat cannot be obtained from the exhaust under any circumstances, either at full load or idling, to heat the motorcoach in accordance with the requirements set forth. To heat a motorcoach properly, heat must be taken from more than one source, the reason being that, although the losses in the exhaust are great, probably great enough even when idling if they could be utilized, only a very small percentage of the total drop in temperature from, say, 1100 to 200 or 300 deg. fahr. which passes out in the exhaust could be used. The amount used is probably 10 per cent of the 25 per cent that is available. That is not sufficient.

MR. MAYER:—Has Mr. Josephs any figures as to the temperature of the exhaust gas at a point, say, where the heater valve is located?

MR. JOSEPHS:—When running at full speed with the throttle wide open, the temperature is sometimes as high as 1300 deg. fahr. at the heater valve, but, in figuring on the heating-system, that cannot be counted on. The condition is abnormal. In some cases in operation, the exhaust pipe has been red-hot almost as far back as the valve.

R. E. PLIMPTON[7]:—Trouble is experienced more often with leakage inside the motorcoach than with the gases that come in after they have been discharged. Mr. Josephs has said that a thin seamless steel tubing is the best form of piping. I know of some operators who have discarded seamless-steel tubing because keeping the joints tight is so much trouble.

[6] M.S.A.E.—Manager, Rushmore Laboratory, Plainfield, N. J.

[7] M.S.A.E.—Associate editor, *Bus Transportation*, New York City.

THE FINANCIAL POSITION OF FRANCE

THE total French public debt, with the franc at par, equals or exceeds the total national wealth. This total national wealth, including all the real estate, railroads, factory and farm equipment, foreign securities, gold and silver, goods on shelves, and the like, was estimated at about 300,000,000,000 gold frances before the war, and, with the addition of Alsace-Lorraine, is probably about as great today, despite the war losses. The total internal debt of France stood on Dec. 31, 1925, at 309,000,000,000 paper francs and 41,000,000,000 gold francs, or 350,000,000,000 gold francs in the aggregate, if the paper franc is taken at par. This would be an impossible burden.

But the decline in the paper franc reduced the gold value of the internal debt enormously. The gold value of the foreign debt has not been affected, one way or the other, by the decline of the paper franc, but the pending settlements with the United States and Great Britain, if carried through, will cut this item by nearly one-half. The total public debt exceeded 34,000,000,000 gold francs in July, 1914.

France has had an appalling unbalance in her budget. Expenditures have exceeded taxes and other revenues enormously since the war, and the public debt has grown by leaps and bounds. Considerable confusion has arisen in the figures, due to the existence not only of "the budget," but also of "the special budget, recoverable" (from Germany); the "special budget, not recoverable"; the "annexed budgets"; and the "special accounts." France made a real fiscal effort in 1924 and 1925. Expenditures have been held in check, and revenues have been sharply increased. The deficit in 1925 is certainly much smaller than any that has preceded it since the war. New taxes have lately been voted, in December, 1925, and early in 1926.

Germany relied primarily on direct taxes, payable in any given year, on the basis of valuations of the preceding year. With the decline in the mark, expenditures shot up greatly while revenues lagged far behind. In France, on the contrary, the expenditures seem even to lag behind revenues, with a fall in the franc, so that a sharp fall in the franc actually improves the budget position. France is subject to no such outside pressure for payments as was Germany. Whether or no German taxes would permit reparation payments, the payments had to be made, and the Government was obliged to resort to the Reischbank for loans, with the result of an immense printing of marks. The Government was also obliged to resort to the bank to meet the current expenses that taxes on the previous year's valuations would not meet. France, on the other hand, has had to have resort to the bank primarily in connection with certain maturities of her internal short-term debt during the last 2 years.

Until recently the French people have lived in the midst of financial illusions, many of them looking forward to the restoration of the franc to par, and most of them counting on a sharp rise in the franc above the 5 and 6-cent level at which it had been holding. The last 2 years have seen a spread of financial information in France of a very thoroughgoing sort and a disillusionment that has led to a great pessimism; a pessimism, in my judgment, fully as exaggerated as was the optimism of 3 years ago. The result has been a tremendous pressure on the part of large elements of the population to exchange their francs and franc securities for foreign values, stable in gold, a "flight from the franc" which has placed a terrific burden upon the exchange rate. Efforts have been made to check this by limitations upon exchange trading, by forbidding the export of securities, by forbidding loans in francs by French banks to foreigners, and even by regulations affecting exports and imports. These efforts have probably intensified rather than lessened the difficulties. At best, a government can control only the outflow of capital and this only partially. It cannot control the reverse flow.

In summary, the great break in the franc has already solved the major financial problems of France. It (*a*) has made the debt burden bearable, (*b*) has helped bring about budgetary balance, (*c*) has placed the Bank of France in a strong reserve position, and (*d*) permits France to look forward to a further period of rising prices during which business will be good and the consolidation of public debt can easily be achieved. The time is opportune for a definite stabilization by the immediate resumption of the gold standard at a new par. This stabilization itself, accompanied by a skillful technical handling of the state finances, will straighten out the whole situation without further drastic sacrifices on the part of anybody. The sacrifices have already been made in the decline of the franc.—B. M. Anderson, Chase National Bank.

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Engine Requirements of Interurban Motorcoach Service

By L. P. KALB[1]

METROPOLITAN SECTION PAPER *Illustrated with* CHARTS

ABSTRACT

GREATER demands are made upon the engine in interurban motorcoach operation than are met in any other type of vehicle because of the high sustained speeds over long distances with nearly full-open throttle and a load that is greater in proportion to size of the engine than in passenger automobiles. Moreover, the motorcoach is operated many more miles per year than any other type of motor vehicle, extremely long life and a high degree of reliability are demanded and efficiency is essential to profitable operation. The author analyzes the requirements of an engine for a 29-passenger interurban motorcoach as to piston displacement, accelerative ability of the vehicle, fuel consumption, number of cylinders, engine speed, and relation of horsepower available to power required to propel the vehicle with various gear-ratios.

Extreme economy in fuel and oil consumption may result in loss of all-round efficiency and reduction in earning capacity through loss of accelerative and hill-climbing ability and unduly high maintenance-cost. Smoothness of operation is demanded by passengers who are accustomed to riding in six and eight-cylinder automobiles, hence the six-cylinder engine is preferable to the four-cylinder engine for motorcoach work, and it is advisable to govern the engine speed at 1800 r.p.m.

The most important consideration is that the engine shall have a piston displacement sufficient to develop the torque required for good acceleration with a gear-ratio that will not require excessive engine-speed at the necessary maximum vehicle-speed. For a sustained vehicle-speed of 45 m.p.h., with an engine-speed not much above 1800 r.p.m., a gear-ratio of 4¼ to 1 is best.

The ability coefficient, or hill-climbing ability, of interurban motorcoaches is approximately 0.500 as compared with 0.110 for passenger cars and 0.075 for heavy-duty trucks, hence the driver must use his change-speed gears more than the driver of a passenger car or a truck. A small high-speed engine may develop the same horsepower as a larger slow-speed engine but it gives lower accelerative ability and the bearing-loads are much greater. The severe service calls for very rugged construction, yet the necessity of weight-limitation prevents undue liberality in proportions. hence extreme care is requisite in designing all parts and in the choice of materials. The author therefore proceeds to point out specifically how the requirements should be met and concludes with the statement that the modern motorcoach engine meets the requirements imposed by the severity of high-speed motorcoach service in an extremely satisfactory way, yet will be still further perfected.

INTERURBAN motorcoach operation undoubtedly makes greater demands upon the engine than are met in any other type of automotive vehicle. The principal factors contributing to the severity of this service are high sustained speeds and long periods of operation with nearly full throttle-opening. Interurban coaches are called upon to maintain higher average speed than most passenger cars and the load carried is greater in proportion to the size of the engine.

In addition to the intensity of power output, the motorcoach is operated many more miles per year than any other type of vehicle, yet profitable operation demands extremely long life and a high degree of reliability; tie-ups due to mechanical failures cannot be tolerated, adjustments and repairs must be few and easily made, and, finally, the period between major overhauls must be extended far beyond that considered satisfactory in other fields of automotive service. Efficiency is also essential to profitable operation and must include low fuel and oil consumption, maintenance economy and efficient earning-ability.

EXCESS ECONOMY MAY DEFEAT EFFICIENCY

It is possible to lay too much stress on fuel-and-oil economy and thereby defeat the object of all-round efficiency. As F. R. Fageol pointed out in his paper[2] presented at the 1926 Annual Meeting of the Society, extreme oil-economy may easily result in reduction in engine life, unduly high maintenance-cost and reduction in earnings due to excessive lost time. Extreme fuel-economy may also result in loss of all-round efficiency due to reduced earning-capacity. Other things being equal, the fuel consumption and accelerative ability of a vehicle are proportionate to the same factors. Fuel consumption is proportionate to the piston displacement per unit of distance travelled, thus

$$Q = 20,168 \times V \times R/D \quad (1)$$

where

D = rolling diameter of tires in inches
Q = piston displacement in cubic inches per mile
R = gear-ratio
V = piston displacement in cubic inches

On the other hand, the propelling force at the tires, and consequently the accelerative and hill-climbing ability of the vehicle, is expressed by the formula

$$F_p = (12.15\, V \times R)/D \quad (2)$$

It can be seen from this that, if an attempt is made to attain too high a fuel economy by reducing either the engine size or the gear-ratio, there will be a corresponding loss in acceleration that may result in a greater decrease of revenue than the saving in fuel-cost. This holds good especially for coach operation in the city where frequent stops are required. In interurban work it may be advisable to make a greater sacrifice of accelerative ability in the interests of fuel economy.

GOOD ACCELERATION AND SMOOTH OPERATION DEMANDED

Another fact pointed out by Mr. Fageol and which must be borne in mind, however, is that motorcoach performance must compare favorably with that of the passenger automobile if the service is to attract the riding public. This applies to acceleration as well as to

[1] M.S.A.E.—Assistant chief engineer, Continental Motors Corporation, Detroit.

[2] See THE JOURNAL, July, 1926, p. 33.

top speed. A coach that is to hold its own in traffic and maintain good average speed must be able not only to develop a good top speed but to reach this speed quickly.

Smoothness of operation is another passenger-automobile standard of performance that must be maintained. The public, educated to the smooth performance of the six or eight-cylinder automobile, does not take kindly to the roughness of a four-cylinder truck-engine in a motorcoach. The unbalanced inertia forces that are inherent in four-cylinder engines are much more objectionable in a motorcoach engine than in a passenger-car engine, mainly because the reciprocating weights are greater in the larger engine and also because motorcoach engines run faster, as a rule, than four-cylinder passenger-car engines. Comparison of the speeds and gear-ratios of coaches with those of some of the well-known four-cylinder passenger cars will show why this is so.

Attempts have been made to minimize the objectionable effects of these vibrations by flexible engine-mountings and balancing mechanisms. Use of the six-cylinder engine, however, with its inherent balance, is the logical solution of this problem. It not only eliminates the so-called secondary inertia-forces but it offers a flexibility and range of operation that are impossible with fewer cylinders.

The torque and horsepower curves of a six-cylinder engine of 420-cu. in. piston displacement and a four-cylinder engine of 425-cu. in displacement are shown in Fig. 1. These curves indicate clearly why the six-cylinder engine will excel the four-cylinder engine in both low-speed and high-speed performance and in acceleration.

Determination of Proper Engine Size

The most important consideration of all is that the engine be large enough for its job, no matter how many cylinders there are or what type of engine is used. The piston displacement must be sufficient to develop the torque required for good acceleration with a gear-ratio that will not require excessive engine-speed at the necessary maximum vehicle-speed. The latter part of this specification is most important because of the effect of engine-speed on engine life; in fact, the limitation of engine-speed dictates the size of the engine.

The first step, therefore, in determining the proper size of engine for a motorcoach is to determine the gear-ratio that will give the proper relationship between the car and engine-speeds. This relationship is expressed by the formula

$$R = (N \times D)/(336.13 \times S) \qquad (3)$$

where

D = rolling diameter of the tires in inches
N = engine-speed in revolutions per minute
R = gear-ratio
S = vehicle speed in miles per hour

Since motorcoach speeds are at least equal to those of passenger cars, and large engines should not run faster than the lighter passenger-car engines, the gear-ratios for interurban coaches should be somewhat less than those used in passenger cars. Experience has shown that, for good engine-life, the sustained speed of the engine should not be much above 1800 r.p.m. Therefore, for a sustained coach speed of 45 m.p.h., we find, by substituting in formula (3), that the gear-ratio should be approximately $4\frac{1}{2}$ to 1 with 36-in. tires. As the gear-ratios employed in present practice are somewhat greater than this, being generally between 4.6 and 5.0 to 1.0, it is apparent that either there must be a sacrifice in top speed or the engine-speed must be somewhat higher than is desirable.

Having determined the gear-ratio, the size of engine necessary for the desired ability may be found by the formula

$$F_p = (12.15\,V \times R)/(D \times W) \qquad (4)$$

where

D = rolling diameter of tires
F_p = propelling force at drive wheels in pounds per pound carried. This is an index of the accelerative, or hill-climbing, ability of the vehicle and is known as the ability coefficient
R = gear-ratio
V = piston displacement in cubic inches
W = total weight of vehicle

Rearranging and solving for V, we have

$$V = (F_p \times D \times W)/12.15\,R \qquad (5)$$

Relation of Required and Available Power

Although it is desirable that the performance of a motorcoach should compare favorably with that of a passenger car, an engine that would assure such performance would be much larger than any motorcoach engine now in use. Passenger cars usually have an ability coefficient of about 0.11. Substituting this value of F_p in formula (5), the necessary displacement can be determined for a 29-passenger coach weighing 17,000 lb. and having a gear-ratio of $4\frac{1}{4}$ to 1 and a wheel diameter of 36 in., as follows:

$$V = (0.11 \times 36 \times 17{,}000)/(12.15 \times 4.25) = 1300 \text{ cu. in.}$$

This displacement is more than double that of any engine used in actual practice. It is evident, therefore, that it is necessary either to sacrifice ability or to increase the engine-speeds beyond 1800 r.p.m. Examination of practice will show that interurban coaches have ability coefficients in the neighborhood of 0.050 as compared with 0.110 for passenger cars and 0.075 for heavy-duty trucks. The coach driver must, therefore, use his gears much more than the driver of a passenger car or a truck.

In determining the size of engine for use in a high-speed coach, we must, of course, make certain that the engine is capable of developing the horsepower required to propel the coach at the desired speed; in fact, there should be an ample margin between the available horsepower at the maximum desired engine-speed and the horsepower required at the desired maximum vehicle-speed. The required horsepower can be found by the formula

$$\text{Hp.} = (0.0175\,W + 0.0129\,A \times S^2)\,S/318 \qquad (6)$$

where

A = total frontal-area
S = vehicle speed in miles per hour
W = total weight of the vehicle

The best means of comparing the power required with that available is to plot both on the same sheet, as in Fig. 2, where we have a curve showing the power required to propel a 29-passenger coach weighing 17,000 lb. and having a frontal area of 45 sq. ft. On the same sheet is the power curve of a 549-cu. in. engine, plotted to three scales for gear-ratios of $4\frac{1}{4}$, 5 and 6 to 1 and a wheel diameter of 36 in. in each case. The curve for the ratio of $4\frac{1}{4}$ to 1 evidently gives the best condition, as the curve of power available intersects the curve of required power at the peak of the former. This intersection is far enough above the desired coach-speed to compensate for variations in either required or available power.

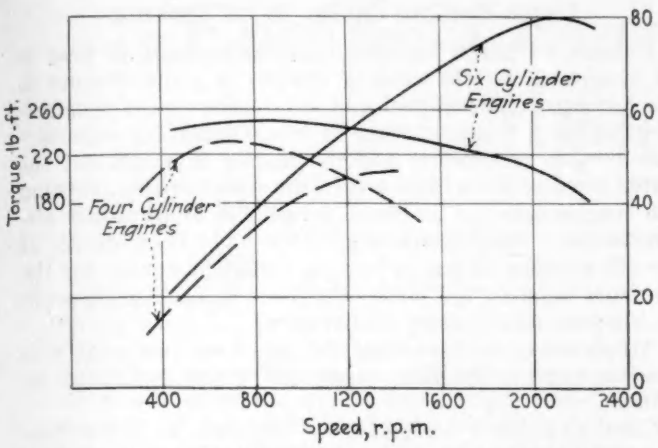

FIG. 1—TORQUE AND HORSEPOWER CURVES OF A SIX-CYLINDER AND A FOUR-CYLINDER ENGINE

The Piston Displacement of the Six-Cylinder Engine Is 420 Cu. In. and That of the Four-Cylinder Engine, 425 Cu. In. Comparison of the Two Sets of Curves Shows Clearly Why the Six-Cylinder Engine Excels the Four-Cylinder Engine in Vehicle Acceleration and Maximum Speed in Both Low and High-Speed Gear

LARGE MODERATE-SPEED ENGINE PREFERABLE

It is, of course, possible to design a smaller engine so that it will deliver the necessary horsepower. It is not a simple matter, however, to increase the torque per cubic inch correspondingly. A smaller piston-displacement could, therefore, mean even lower accelerative-ability than the figure given. Owing to the low accelerative-ability of interurban coaches, there is always the temptation to improve performance by increasing the gear-ratio, hence, it is desirable to limit the engine-speed by a governor. As some of the best truck-engines were governed in the neighborhood of 1000 r.p.m. only a few years ago, it should not be thought unreasonable to govern a motorcoach engine at 1800 r.p.m.; in fact, this governed speed is so far above the torque-peak that it does not affect the pulling or acceleration of the engine at all.

A governor is, if anything, more necessary with a six than with a four-cylinder engine, not that the former needs it more; quite the contrary. The inherent smoothness of a six-cylinder engine, however, allows it to be operated at excessive speed without discomfort or warning to the driver.

It must be borne in mind that centrifugal and inertia forces increase in proportion to the square of the engine-speed while the power output does not increase even as the first power. I have recently compared these loads in two actual engines, one of 549 and the other of 268-cu. in. displacement. Since the larger engine develops twice the torque of the smaller one, the gear-ratio can be one-half that used with the latter if the two engines are to have the same ability in vehicles of the same weight. This would mean that for the same car-speed the engine-speed of the smaller engine would be twice that of the larger. Consequently, I have calculated the bearing-loads at 1500 r.p.m. for the larger engine and at 3000 r.p.m. for the smaller.

The bearing-loads of the smaller engine are more than three times those of the larger one. Even if bearings of the same size were used in both engines, the bearing-loads of the smaller engine would still be more than double those of the larger one.

DESIGN AND MATERIAL REQUIREMENTS

The engine in an interurban coach is subject to very severe service even when operating under the best of conditions and must be very ruggedly constructed to stand-up in this service. The necessity for weight-limitation, on the other hand, prevents undue liberality in proportions. This restriction calls for extreme care in the designing of all parts and in the choice of materials. Bearing-surfaces must be ample and well lubricated. The preferable number of main bearings in a six-cylinder engine is seven, because more bearing area can be crowded into a given space than when fewer bearings are used. This construction, by providing support on each side of each crankpin, eliminates transverse deflection of the crankshaft and prevents uneven wear of the main and connecting-rod bearings. When a four-bearing construction is used, it is advisable to counterbalance the crankshaft.

The crankshaft should be stiff enough to avoid the occurrence of bad torsional-periods within the range of operating speeds. This calls for bearings of large diameter and, to reduce torsional vibrations still further, it is advisable to incorporate a torsional vibration-dampener such as the Lanchester. A large quantity of oil must be circulated through the bearings to compensate for friction due to the high bearing-speeds. The lubrication of all bearings, even the piston-pin, should be by pressure.

It has been found that the best practice is to babbitt the connecting-rods and main-bearing caps directly, as this construction affords the best heat-dissipation and also provides a bearing that cannot hammer loose.

Reciprocating parts must be as light as possible to

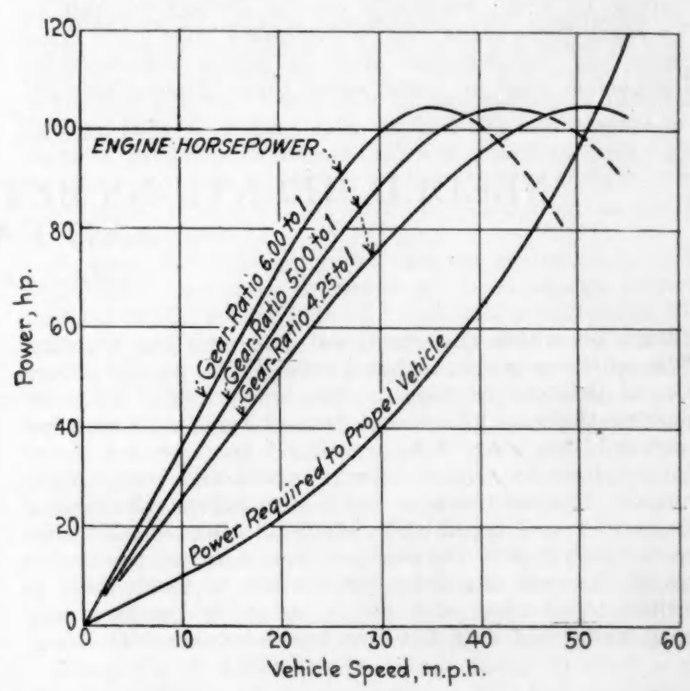

FIG. 2—RELATION OF POWER DEVELOPED TO POWER REQUIRED TO PROPEL VEHICLES

The Curve of Power Required Is for the Operation on a Level Road of a 29-Passenger Motorcoach Weighing 17,000 Lb. and Having a Frontal Area of 45 Sq. Ft. The Engine Horsepower Curves Are for an Engine of 549-Cu. In. Piston Displacement and Are Plotted to Three Scales for Gear-Ratios as Shown in the Table Below. The Required Horsepower Is Found by Formula (6). A Gear-Ratio of 4¼ to 1 Gives the Best Conditions, As the Curve of Available Power Intersects the Curve of Required Power at the Peak of the Former

Gear-Ratios Vehicle Speed, M.P.H.	4.25 to 1 R.P.M.	5.00 to 1 R.P.M.	6.00 to 1 R.P.M.
10	396	467	558
20	793	934	1,117
30	1,190	1,400	1,675
40	1,586	1,866	2,230
50	1,981	2,330	2,790
60	2,400	2,800	....

minimize the reciprocating forces. At the same time the piston must be capable of dissipating a large amount of heat rapidly and must be free from distortion. Piston-pin bearing-areas must be ample and the connecting-rod must stand-up under high reciprocating-loads without fatigue.

Valves must be made of material that has high resistance to pitting and warping and that retains its strength and hardness at high temperatures. Valve-seats must have ample area, both to dissipate the heat and to keep the unit pressure low. Valve-springs must have a low range of stress and must not be subject to undue periodic vibrations within the normal range of speed.

The cylinders must be of hard close-grained iron, with ample water spaces, especially around the valves, and a large quantity of water must be circulated.

The crankcases of these large engines must be of aluminum if the weight is to be held within reason I consider it desirable to use an aluminum alloy similar in composition to duralumin which can be heat-treated to give properties considerably better than those of the alloys commonly used for aluminum castings.

The driving of the numerous engine-accessories required by coach service is no small problem in itself. Lighting generators are large and the inertia of the armatures is in proportion. Fans of 22 and 24-in. diameter that require up to 5 hp. to drive are used commonly. Air compressors, with their pulsating loads, impose no small resistance on the driving mechanism. To carry these loads, the timing-gears must have broad faces and the material must be either case-hardened low-carbon steel or heat-treated high-carbon alloy-steel.

Under-Cooling Causes Much Trouble

It must be borne in mind that the amount of heat to be dissipated by the cooling system is proportionate to the horsepower developed and not to the piston displacement alone. Under-cooling is responsible for considerable trouble on coaches and, no matter how efficient the water circulation or how ample the water spaces, nothing can compensate for too small a radiator or improper air-circulation. Motorcoach engineers have been guilty of the old mistake of not providing sufficient egress for the air from beneath the hood. Apparently each must profit by his own mistakes in this regard.

Air-cleaning and oil-filtration are two means of prolonging engine life that cannot be given too much attention.

Gasoline-electric drive is to be favored, so far as concerns the engine, if for no other reason than that it provides an absolutely foolproof governor.

Despite the severity of high-speed motorcoach service, the modern coach engine is meeting the requirements in an extremely satisfactory way, yet these engines will be further perfected and will give even more satisfactory performance than they do now. An important factor in this continued improvement is the fact that operators are realizing more and more what they must do in the way of improving operating conditions, limiting speed and providing systematic inspection and maintenance.

The interurban motorcoach has demonstrated its right to a permanent place in transportation. There is no doubt that, as it becomes more efficient and reliable, it will continue to grow in public favor, even more rapidly than it has in the last few years.

NEEDED RELATIONS BETWEEN SERVICE STATION AND FACTORY

(*Concluded from p.* 172)

things on which they have not had previous training. The work on motorcoaches at the Fifth Avenue Coach Co. is divided into classes. The lowest job of all is removing the rear wheels. It is easy for a man who has any ambition, even if he was hired as a sweeper, to be taught how to remove a rear wheel and put it back again. The next step is for him to adjust the brakes. In an all-round repair shop where all kinds of cars come in, to teach men of the sweeper type to adjust the brakes on all the cars might be difficult, but to teach them to adjust the brakes of a single model is comparatively easy, and I had very few who could not learn it. Many of the men who are doing important engine work for the Fifth Avenue Coach Co. today started at the job of sweeping the floor. The men knew there was a chance of advancement; that was an incentive and the large majority have advanced that way. When I spoke of hiring mechanics as sweepers I meant that we move each man up a grade and, if we hire a sweeper and he shows ability, he will move up to the grades for which he is able to qualify. All do not reach the top but each has an opportunity, and I can assure you that the system has proved in practice to be fundamentally sound from an economic point of view.

STANDARDIZATION WITHOUT RUTS

THE worst enemy of standardization is the man who considers any standard in any line as the last word and uses it as an alibi for not investigating the desirability of new and better methods. To condemn efforts at standardization on that account is, however, a great mistake. The desirability of having parts interchange, of knowing that a Class 1 fit would be the same in all parts of the Country, or that designations of quality meant the same in all cases can hardly be overestimated.

Unquestionably, the tendency is to stick to standards after they have been adopted, and this of itself is an advantage in many ways. But no one should consider either standards or codes as the last word. Both should be criticized constructively and, when sufficient reason for change is presented, amendments or even drastic changes should be made.

The Society of Automotive Engineers has adopted many standards and these have helped to make possible the improved quality and lower prices of automobiles. Yet these standards are constantly under examination, and revisions are made whenever it seems advisable. As an example of standardization without getting into ruts, the automotive industry is a very bright and shining example.—*American Machinist.*

Engine Overhauling in Fleet Maintenance

By W. S. PENFIELD[1]

NORTHERN CALIFORNIA SECTION PAPER

ABSTRACT

THE question of engine overhauling has assumed greater importance for the automotive-fleet repair-shop than ever before, principally because of the reduced cost of engine production and the adoption of the flat-rate system of charges by the factory branch and by service companies. There are advantages to the fleet owner, however, in maintaining a repair-shop in which the work is systematized to provide for periodic repairs at regular mileage-intervals, as a careful analysis of the failures gives an insight into their causes and the detrimental effects of abuse and neglect of the vehicles. The tendency now is for motor-truck and motorcoach operators to provide a system of inspection and preventive measures to forestall failures and defer the overhauls. Too many, however, criticise the overhaul costs and try to reduce them after the vehicles get into the repair-shop. The degree of thoroughness with which the work is done governs the cost, and considerable difference of opinion exists as to what constitutes an engine-overhaul job.

The author lists the operations in their sequence as (*a*) dismantling, (*b*) cleaning, (*c*) inspection, (*d*) estimating, (*e*) assembling, (*f*) running-in, (*g*) testing, and (*h*) final inspection. Of these, reassembling is the most extensive operation and is subdivided into (*a*) cylinder grinding, (*b*) piston replacement, (*c*) crankshaft grinding, (*d*) valve and valve-seat renewals, (*e*) bearing work, (*f*) crankcase aligning, and (*g*) general renewals and repairs.

Passing cursorily over the preliminary operations, the author deals in detail with each subdivision under assembling and tells how to determine when cylinder and crankshaft grinding should be done and describes methods of doing the work that have been found to give satisfactory results. He estimates that about 85 per cent of all cylinder reconditioning is done by grinding and says that grinding while hot water circulates through the cylinder-jacket has advantages. Cast-iron pistons should have a clearance of approximately 0.001 in. for each inch of piston diameter. Some recent experiments have been made to demonstrate that the tendency of pistons to score near the wrist-pin holes when the engine has been returned to service have indicated that this scoring can be prevented by immersing the assembled piston in a hot oil-bath just before the piston is placed in the cylinder. Plain piston-rings, when carefully fitted in accurately machined grooves and having a wall-pressure of 7 lb., give satisfactory results. Most shops use an oil-seal ring in the lower ring-groove.

Valve-grinding is often overdone through the use of improper tools and unsuitable abrasives; and the tendency is toward elimination of grinding by the use of valve-seat reamers and guides. Little has been done toward replacing valve-seats, but many shops rebuild worn seats by the electric-welding torch. Interesting experiments have been made lately in which the valve-seats were counterbored sufficiently large to accommodate a new cast-iron ring-seat, heating the cylinder-block in an oil-bath and forcing the cold ring into position.

Methods in use by the Associated Oil Co. for reconditioning the engine bearings are described, and in conclusion the author expresses the hope that sometime the engine or vehicle builder will recognize more fully and encourage the fleet-maintenance shop as a field laboratory for the beneficial development of his product, since it uncovers numerous weak points in construction that go unnoticed by the owner of a single vehicle or of a small fleet. Nine suggestions for improvement of engines, which may be of interest to both engine builders and repairmen, are offered for discussion, and it is believed that the need for them is well known to many maintenance organizations.

THE problem of engine overhauling that confronts the automotive-fleet repair-shop is more important today than ever before, principally because of the reduced cost of engine building and the flat-rate charges for overhauling offered by the factory branches and the service corporations. Although the flat-rate charges are very attractive, a well-systematized shop operated by the fleet owner is certain to produce better results, if it is so regulated as to provide for periodic and systematic repairs, than if the work is sent to the branch service-station or to a service company. When the work is done in the fleet operator's own shop an opportunity is afforded for carefully analyzing failures and the detrimental effects of neglect and abuses that are practised, and such an analysis surely gives the owner a better insight into the causes of the cost of fleet operation than he could otherwise obtain.

A general tendency exists among motor-truck and motorcoach operators to maintain their vehicles rather than to repair them; that is, to provide a system of inspection and preventive measures whereby certain work is performed at regular mileage-intervals to forestall failures. The cost of engine overhauls depends largely upon whether there is maintenance on the mileage system while the vehicles are in regular operation and upon many other contributing factors, such as handling of the vehicles by the drivers, roads over which they are operated, weather, and the use of safeguarding appliances. Too many operators criticize overhaul costs and endeavor to reduce them after the vehicles get into the repair-shop; the overhaul cost is but a reflection upon the operation and maintenance, as can be proved by a careful analysis.

Considerable difference of opinion seems to exist as to what constitutes an engine-overhaul job; and the degree of thoroughness with which it is done naturally governs the cost of the work. To fix a basis from which to draw conclusions that an engine needs overhauling, let it be assumed that it has been operated for a total of from 35,000 to 45,000 miles or the equivalent thereof in service. The overhaul operations may be listed in their sequence as (*a*) dismantling, (*b*) cleaning, (*c*) inspection, (*d*) estimating, (*e*) assembling, (*f*) running-in, (*g*) testing, and (*h*) final inspection.

Dismantling and cleaning have been accelerated considerably by the aid of speed wrenches operated by compressed air and by hot-chemical vats. Cylinder-blocks are placed in special baths to remove old paint that tends

[1] M.S.A.E. — Superintendent of shops, Associated Oil Co., San Francisco.

to cause overheating when the engine is returned to service.

Inspecting and estimating are important; some corporations and fleet owners require that estimates be submitted before repair work proceeds beyond the inspection point, particularly if the engine is included in the general overhaul of the vehicle. In all cases, the age, mileage and condition of the engine must be considered before the reconditioning work proceeds.

Reassembling is the most extensive operation and is comprised of several subdivisions, such as, (*a*) cylinder grinding, (*b*) piston replacement, (*e*) crankshaft grinding, (*d*) valve and valve-seat renewals, (*e*) bearing work, (*f*) crankcase aligning, and (*g*) general renewals and repairs.

When and How to Regrind Cylinders

The question of whether or not to grind the cylinders is determined by the physical condition of the walls as ascertained by accurate micrometer measurements of the taper and the mean diameter of the bore. A fairly safe rule is to regrind if the taper or out-of-round measurement exceeds 0.005 in. Reconditioning of the cylinder-walls seems to be accomplished best by grinding in preference to boring, honing or reaming. The grinding wheel is not so likely to be affected by glazed surfaces and filled wall-scores as the boring bar. As the result of investigation in a number of repair-shops, it is estimated conservatively that about 85 per cent of all cylinder reconditioning is accomplished by grinding.

Some shops grind the blocks cold but a few have obtained very pleasing results by grinding the cylinders while a hot-water bath circulates through the cylinder-jackets. This method has some merit because any crack in the jacket is likely to become apparent in time to stop the work without undue loss of labor. Very few shops regrind blocks more than the fourth time, removing about 0.015 in. of metal at each grinding. The average engine-block will stand the removal of about 0.060 in. from the cylinder diameter, but it is doubtful if the block will give further service for a satisfactory period if more than this amount is removed. The thickness of cast cylinder-walls sometimes varies ⅛ in.

Some shops grind both the cylinder-walls and the pistons, but fairly good results can be obtained by grinding the walls and turning the pistons, after which the pistons are allowed to produce their own wearing surfaces after the engine has been returned to service.

Piston replacement can be accomplished with very good results if a few precautions are followed. The rule for clearance of cast-iron pistons is that it should be approximately 0.001 in. for each inch of piston diameter. The clearance of Lynite and other alloy pistons should be governed by the recommendations of the piston manufacturer. A few shops still recommend the use of alloy or Lynite pistons, but it is noticeable that most of the prominent engine builders have returned to the use of cast-iron pistons because of their longer life and the general demand by conservative repairmen.

When installing wrist-pins in Lynite pistons, it is always advisable to warm the piston to approximately 125 deg. fahr. or more. Pistons have a tendency to score near the wrist-pin hole shortly after the engine has been returned to service; and some interesting experiments were made in the last year to demonstrate that this scoring can be prevented by submerging the assembled piston in an oil-bath at a temperature of 350 deg. fahr. just before it is placed in the cylinder.

Piston-ring replacement is important, and a good rule to follow in choosing rings for maximum service is to have 7-lb. wall-pressure. Although there is a great variety of plain and multiple rings, a plain ring, when carefully fitted to accurately machined grooves, seems to give satisfactory results in many shops. Nearly all repair-shops use an oil-seal ring in the lower ring-groove and find that it gives satisfaction.

Crankshaft Grinding-Wheels and Baths

Crankshaft grinding is usually a necessary operation in engine overhauling, particularly on soft-steel shafts. Many engine builders, however, are heat-treating their shafts to delay the need for regrinding. One well-known builder case-hardens the shaft to a depth of approximately 1/16 in., with the result that regrinding is not necessary before the engine has been operated for 100,000 miles.

To give good bearing life, the crankshaft should be reground if the diameter is out-of-round in excess of 0.002 in. The importance of the selection of a grinding wheel as to grit, grade, bond, and the like cannot be overestimated. Particularly good results can be gained by using a 24 combination M or N Norton grinding wheel and a circulating bath made of 4 lb. of Oakite and 1 gal. of soluble oil to a barrel of water. This mixture will prevent the grinding wheel from glazing and from undercutting without too much recourse to the diamond-point dresser.

Tendency To Eliminate Valve Grinding

Valve grinding is often overdone through the use of improper tools and unsuitable abrasives. The general trend seems to be toward elimination of valve grinding and the use instead of accurate valve-seat reamers and guides. Several good reamers and fixtures are on the market that will produce a seat that is sufficiently accurate to make grinding unnecessary.

Little has been done toward the replacing of valve-seats that have been reground and counterbored to such an extent that reconditioning is imperative. Many shops rebuild the worn seats by the electric-welding torch. This is fairly good practice, although a block is spoiled occasionally because of the distortion due to the heat and considerable time is consumed in remachining. Some interesting experiments have been made recently in which the valve-seat was counterbored sufficiently large to accommodate a new cast-iron seat-ring. The cylinder-block was then immersed in an oil-bath heated to approximately 350 deg. fahr. and the cold ring forced into position.

A new type of exhaust valve that requires a very wide valve-seat is now being manufactured under the name Multi-Seal Valve. The face is grooved in two or more places and the V-shaped grooves become filled with carbon which keeps the valve-head cool and prevents the burning and warping of the valve.

How Bearings Are Reconditioned

Several methods followed in reconditioning bearings are hand-scraping, reaming, broaching, and boring. The most common is scraping and hand-fitting, but many shops obtain good results by reaming. Broaching has made little headway in repair work because of the multitude of types and sizes of broach required for the various altered dimensions; the standardization of bearing diameters in accordance with the size and other characteristics of the engine is much to be desired from a maintenance point of view.

Methods at present in use in the repair-shop of the Associated Oil Co., in which the general repair work is divided among 12 specialized departments, are as follows: The crankcase and connecting-rods are first inspected and

tested for alignment, cracks and other defects; the old bearings are discarded and new undersize bearings are fitted and anchored into position; the crankcase, crankshaft and rods are then sent to the machine-tool department for grinding or boring as the case may require. There the crankcase is fastened to the horizontal boring-machine table and the boring bar, with single-fly cutters, bores the main bearings to size. The crankshaft is then adjusted to position and the main bearings are burnished.

The connecting-rod bearings are bored in a similar way on a pedestal boring-machine and are then adjusted to the crankshaft bearings and also burnished. Both the main and the connecting-rod bearings are bored and burnished without removing the crankcase from the boring-machine table. The crankcase, crankshaft and connecting-rods are then returned to the engine department for fitting, shimming and assembling. The rods and pistons are assembled and placed in hot oil-baths before attaching them to the crankshaft and putting on the cylinder-block.

After the engine has been assembled, it is placed on the running-in stand and belted-in for a period of from 2 to 4 hr. The gasoline line and the water lines are then attached and the engine is run under its own power with a predetermined load for another period of from 2 to 4 hr. The oil-pan is then removed for final inspection, the engine-records compiled and the job is finished for immediate installation or is shipped out for use as occasion requires. In cases of unit powerplant, the gear department overhauls the transmission while the engine is being overhauled.

Fleet Maintenance-Shop Uncovers Weak Points

A continued repair-shop production of approximately 30 overhauled engines per month is sure to uncover numerous weak points of construction that are not ordinarily noticed by the owner of a single vehicle, by the small-fleet owner or by the engine or vehicle builder. It is to be hoped that sometime the builder will recognize more fully and encourage the fleet-maintenance shop as a field laboratory for the beneficial development of his product. Surely the large shop is willing to cooperate with him to eliminate the premature failures that now occur. The repair-shop management frequently hesitates to criticize the factory, but it is common knowledge in the repair-shops that connecting-rod fatigue and fracture are not uncommon soon after 25,000 miles of service, that valve failures are too common around 5000 miles, and that many other failures occur too soon.

The following suggestions may be of interest both to engine builders and to repair-shop men. There is reason for believing that the need for some of them is well known to many maintenance organizations, and discussion of them is invited.

(1) Standardized engine-bearing dimensions in accordance with engine size. This applies not only to internal dimensions but to external and installation dimensions as well
(2) Standardized crankcase filler and drain-plug
(3) Standardized engine-suspension
(4) Non-corrosive water-pump shafts
(5) More general elimination of the unit powerplant
(6) Centralized and better oil and air filtering within the unit while the engine is in operation and better dust protection while the unit is idle
(7) Elimination of crankcase-oil dilution without resort by the vehicle user to attachments or accessories that are not incorporated in the engine by the builder
(8) Less manifold-restriction and better control of the air temperature required for satisfactory carburetion
(9) More frequent interchange of technical data and information between the factory and the repair-shop

LIST OF COMMERCIAL TESTING LABORATORIES

In recognition of the desirability under present conditions of independent commercial testing service and in anticipation of a marked increase in the demand for such service in both domestic and export trade, the Bureau of Standards is making as nearly complete and accurate as possible its list of laboratories throughout the Country which are prepared to test various kinds of commodities to determine whether or not they comply with purchase specifications. In this list will be included the laboratories of universities and colleges which are equipped for doing commodity acceptance testing on either a purely commercial basis or for the purchasers of the States, municipalities, public institutions, or the schools themselves.

The existence of a thoroughly classified list of commercial testing laboratories, together with a list of other reliable "checking agencies," will have a number of beneficial effects in promoting the use of specifications, not the least important of which will be the inducement offered to the large number of purchasers who have hitherto hesitated to buy on specifications.

Heretofore purchasers not individually equipped to make their own acceptance tests have been reluctant to adopt the specification method of buying commodities because of the fixed belief that many manufacturers work off "seconds" on such customers. The knowledge that they can at any time, when they so desire, call upon testing laboratories to check the deliveries made to them on contracts based on specifications with which certificates have been issued by the manufacturers will induce a large number of such purchasers to take full advantage of the certification plan.

The outstanding fact in the specification situation at the present time is that a very great majority of the purchasers who should be using specifications are not doing so. It is to this great group of purchasers that the certification plan will prove most beneficial. If, in addition to obtaining copies of as good specifications as can be written at the present time, all purchasers are able to secure lists of firms willing to manufacture to these specifications and to certify to compliance therewith, and lists of testing laboratories and checking agencies, many of these purchasers will readily adopt the specification method of buying. This is especially true of the purchasers of States and municipalities who are anxious to use specifications but have not thus far felt justified in doing so because of inability to determine whether or not the commodities comply with the specification requirements. —Bureau of Standards Technical News Bulletin.

Applicants *Qualified*

The following applicants have qualified for admission to the Society between June 10, and July 10, 1926. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member.

AGLER, WILLIAM B. (A) district mechanic, Associated Oil Co., *Los Angeles;* (mail) 250 South Avenue, 54.

BABIKOFF, VLADIMIR VASILIEVICH (A) sales engineer, International Motor Co., Anable Avenue and 34th Street, *Long Island City, N. Y.*

BACON, W. WARDER, JR. (J) supervisor of automotive transportation equipment, Sesquicentennial Exhibition Association, Philadelphia; (mail) 140 Linwood Avenue, *Ardmore, Pa.*

BAKKEN, H. E. (M) superintendent, American Magnesium Corporation, *Niagara Falls, N. Y.*

BALDAUF, PH., JR. (J) body engineer, Sayers & Scovill Co., Gest and Summer Streets, *Cincinnati.*

BALLARD, J. H. (A) superintendent, Acme Motor Truck Co., *Cadillac, Mich.;* (mail) 442 East Harris Street.

BEAL, W. HUBERT (A) sales manager, Lycoming Mfg. Co., *Williamsport, Pa.;* (mail) 921 Campbell Street.

BOYD, MERVYN J. (A) service superintendent, Federal Motor Truck Co., 1350 Howard Street, *San Francisco.*

BOYD, PAUL M. (J) production engineer, engineering department, Curtiss Airplane & Motor Co., Inc., *Garden City, N. Y.*

BRIGHT, THOMAS C. (A) manager of tubing sales, Rome Mfg. Co., *Rome, N. Y.;* (mail) 306 Elm Street.

BRION, LESTER (A) president, Peter A. Frasse & Co., Inc., Grand and Sullivan Streets, *New York City.*

BRUCE, CLARENCE S. (S M) aviation mechanic, Bureau of Standards, *City of Washington;* (mail) 4203 16th Street, Northwest.

BURGESS, LAURENCE E. (J) experimental engineer, International Motor Co., *Allentown, Pa.;* (mail) 212 South 13th Street.

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Applicants *for* Membership

The applications for membership received between June 15 and July 15, 1926, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ALLEN, EVERETT W., chief draftsman, Yellow Sleeve Valve Engine Works, Inc., *East Moline, Ill.*

BAKEWELL, W. E., draftsman, Graham Bros., *Evansville, Ind.*

BEARD, FREDERICK WILLIAM, director, secretary and treasurer, General Motors, Ltd., *London, N. W. 9, England.*

BEST, PERCY, automobile designer, Pierce-Arrow Motor Car Co., *Buffalo.*

BISHOP, G. E., president, Bishop Products Co., *Cleveland.*

BURBANK, WENDELL F., assistant manager of sales research department, White Co., *Cleveland.*

BURNSIDE, H. D., factory manager, Clark Tructractor Co., *Battle Creek, Mich.*

FELSECKER, E. J., service manager, Graver-Bartlett Nash Co., *Hammond, Ind.*

FOLLENSBY, R. A., sales engineer, Whitney Mfg. Co., *Hartford, Conn.*

GOSSELIN, JOSEPH A., service man, Leghorn Motors Co., *Boston.*

GUSTAFSON, ALFRED N., chief engineer, Schramm, Inc., *West Chester, Pa.*

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KELSO, A. R., works manager, Continental Motors Corporation, *Muskegon, Mich.*

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McCANN, GEORGE, draftsman, Willys-Overland Co., *Toledo.*

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MAXIM, ERNEST L., treasurer, Maxim Motor Co., *Middleboro, Mass.*

MILLER, WELLINGTON EVERETT, designer-draftsman, Locke & Co., *Rochester, N. Y.*

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PARNELL, FRANK GORDON, automobile designer, Triumph Cycle Co., Ltd., *Coventry, England.*

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